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NEW ZEALAND.

TELEGRAPH AND TELEPHONE MATTERS IN AMERICA AND EUROPE

(REPORT OF CHIEF ELECTRICIAN, POST AND TELEGRAPH DEPARTMENT, ON).

Laid on the Table of the House by leave.

The SECRETARY, General Post Office, to the Hon. the POSTMASTER-GENERAL.

(Memorandum). General Post Office, Wellington, 24th June, 1912.

I BEG to submit the report of Mr. Buckley, Chief Electrician, on his observations on telephone and telegraph matters in America and Europe. Mr. Buckley recommends—

(1.) That the more extended use of the telephone generally should be promoted as far as possible. The development of the telephone in centres of population in the Dominion as compared with that in many other parts of the world is low.

Action has already been taken as far as possible. Later on, as new switchboards are installed, I propose to recommend that canvassers be employed to increase the number of subscribers. I have no doubt that the number can be increased from 50 to 75 per cent.

(2.) That the full automatic system of giving telephone service be adopted for Auckland, Christchurch, Dunedin, and Wellington.

(4.) That the Western Electric Company, London; Messrs. Siemens Bros., London, who supply the Siemens-Halske system; and the Automatic Electric Company, Chicago, who supply the Strowger system, be invited to tender for a full automatic equipment for Wellington.

There is no doubt that full automatic is a pronounced success, and it would be out of the question to adopt any less modern system. At present our switchboards in the chief centres are altogether obsolete, and new exchanges are imperatively necessary, as the present boards are not only costly to work but are becoming worn out and require a considerable annual expenditure for manitenance. Fortunately, we have not adopted in the chief centres the system which came before the automatic was fully developed—namely, the common battery. As the installations at Wellington and Auckland are the most urgent, I would recommend that authority be given for the installation of the automatic system at both places. Leaving ample margin for future developments, the cost will be £40,000 for each place. It is recommended that tenders be called for from the firms named by Mr. Buckley. One of the firms offers to lay down an installation and to maintain it for a year free of cost to the Department provided interest at 4 per cent. is paid until the installation is taken over. If the system is not approved it will be removed without cost to the Department. The other firms should be asked to make a similar offer. The financial aspect of the automatic as compared with the present system will be an annual saving of £2,000 on each installation or, say, £8,000 per annum when the four chief centres are in working-order. This allows for interest and all charges. If, on the other hand, the common battery system is adopted, which is not recommended, the annual cost will be £6,000 more than automatics for the four centres.

As the first installation cannot be completed in less than eighteen months no special vote will be required until the year after next.

If it is decided to adopt the recommendation to install automatics, it is recommended that no more women be employed, and that until the automatic system is working any vacancies in the staff be filled by lads, who can eventually be trained as mechanicians or drafted to the position of letter-carrier, &c. As the process of changing over will be a gradual one and will occupy about five years, I anticipate that with vacancies at country places and the natural wastage of the staff the

female staff will by that time be sufficiently reduced to enable it to be absorbed readily in other directions. There will still be a certain number of women required for long-distance work, as accounts must necessarily be kept of all messages beyond the metropolitan radius.

In addition to working-advantages and the saving in annual cost, I anticipate that the advent of the automatic will enable the metropolitan radius in each centre to be largely increased, and thus avoid such anomalies as higher rates having to be paid for telephones in Newtown than in the City of Wellington.

(3.) That the full automatic system be adopted also for any exchanges at smaller places that may be requiring new equipment—in all cases where after a study of the conditions it may be found that the operation and economic features and the general advantages to the public in respect of the character of the service given would justify it.

It was recently recommended that common battery outfits be obtained for Hamilton, Masterton, Blenheim, and Oamaru. After fuller consideration, the Chief Telegraph Engineer recommends that this be withdrawn in order that the position may be further studied, with the object of finally determining whether automatic switchboards should not be obtained instead. Recommended that tenders for automatic switchboards for these places be also called for. The cost will probably be £3,000 for each place, as against £2,000. The annual charges for day-work will be about the same, but, as the automatic will enable a twenty-four-hour day service to be given, the ultimate expense of providing for night attendance—say, £250 to £300 per annum—will be avoided.

(5.) That studies be made of the four large cities to obtain some idea of what may be the expected development in each—whether it is likely that it will be general throughout an area or more congested in particular parts of the area, and whether any particular parts will be specially difficult and therefore expensive to reach.

(6.) That the question of multi-office or satellite exchanges for the larger places be considered in their economic aspect as compared with giving service from, say, two or three exchanges in the area.

Development studies will be made as early as possible, and recommendations submitted later on.

(8.) That suitable appliances be obtained for determining the effect upon speech of apparatus that must be introduced into telephone circuits, and for enabling the results that may be expected from combinations of circuits which introduce varied kinds and quantities of apparatus to be definitely known.

This question can be dealt with as occasion arises, and authority obtained for further testing apparatus for general work of the Department as may be recommended by the Chief Telegraph Engineer.

(9.) That negotiations be opened with the representatives in the United States of the Wright and of the Morkrum typewriter telegraph apparatus to judge of their suitability for our conditions. These instruments are leased in the United States; they are not sold.

(10.) That quadruple Baudot apparatus be considered for use on the main circuits of the Department throughout the Dominion, and that two sets each for Auckland and Wellington be obtained for use over the circuits between those cities. The cost will be about £1,400 for apparatus.

Recommended that negotiations be opened up with the representatives in the United States of the Wright and the Morkrum typewriter telegraph apparatus, and that in the meantime two sets each of the Baudot multiple-printing telegraph be obtained for use between Auckland and Wellington, at a cost of £1,400. It is also recommended that when this apparatus is ready the British Post Office be asked to lend an officer for four months to instruct our officers and engineers. The cost of passage and salary will not exceed about £250, and against this we will have the use of the officer for four months. The money will be well spent, as experience has proved that it is a great loss of time to install entirely new apparatus without being able to completely instruct our officers beforehand.

(11.) That accumulators be installed for line batteries at the four large centres and a few other places where large numbers of primary cells are now in use. This would be more economical than present methods, and would improve working considerably.

This is an engineering matter. The cost is not great, and it can be dealt with from time to time as the Chief Telegraph Engineer may recommend. In point of fact, it has already been proposed to make a recommendation in connection with the new offices at Auckland and Wellington.

(12.) That the technical staff be increased as may be necessary to give effect to the foregoing and to cope with expected developments.

The training of engineers is being arranged as thoroughly as possible consistent with the number of qualified officers presenting themselves.

Attention is directed to the last paragraph of the Chief Telegraph Engineer's memorandum as showing the urgent necessity for immediate action in the direction of providing modern telephone equipments. Unless the new equipment is ready in Wellington, the ultimate capacity of the present switchboard will be reached within two years, when we shall simply have to close down as regards new business. Similar conditions apply to Auckland. As the income of the Wellington and Auckland exchanges is increasing at the rate of about £2,000 per annum each, the practical nature of the question is apparent.

To provide new expenditure of capital for the switchboards for the four centres I estimate that a sum of £40,000 will be required in each of the years 1914, 1915, 1916, and 1917, to which should be added a total of £12,000 for the four smaller places named above, the expenditure for which will probably fall into the same years.

It gives me much pleasure to call the Postmaster-General's attention to the very exhaustive and complete nature of Mr. Buckley's report and to the value of the conclusions arrived at. If the Postmaster-General agrees with my view, I would suggest that special thanks be given to Mr. Buckley. In no other way than a personal visit to America and Europe could such valuable information have been obtained. With the rapid developments in telephone engineering, it would be profitable to the Department to send its most able officers occasionally to America or Europe, particularly to America, to report on developments from time to time.

The Hon. the Postmaster-General. D. ROBERTSON.

The CHIEF TELEGRAPH ENGINEER to the SECRETARY, General Post Office, Wellington.

(Memorandum.) General Post Office, Wellington, 22nd June, 1912.

HEREUNDER are my recommendations and comments regarding the immediate action that should be taken in reference to the subjects referred to in the synopsis of Mr. Buckley's report.

(1.) Action in this direction has already been taken in framing the revised tariff and party-line system, which came into operation on the 1st of January last. A marked increase of applications for connections is now taking place, especially at the country exchanges.

(2 and 4.) Full automatic has proved itself an undoubted success, and is being operated elsewhere with every satisfaction to the public and the operating companies concerned. Its economic and technical advantages are outlined in the report, and it seems destined to become the system of the future.

The four chief centres are all in need of a new outfit, but Wellington is the most pressing, and as it affords a suitable field for a close observation of the merits of the automatic system I recommend that full automatic be decided upon for Wellington, and that the firms referred to in paragraph 4 of the synopsis be supplied with full particulars of our requirements and be invited to tender for a suitable equipment.

(3.) There are important economic and commercial benefits derived from having a homogeneous system of automatics over intercommunicating areas, such as all-night service and economic working of toll lines at night-time without the need of toll operators at any but the central exchanges. I therefore recommend that, in addition to calling for quotations for central-battery plants at Hamilton, Masterton, Blenheim, and Oamaru, as already decided, a development study of these places be undertaken with a view to seeing if these areas lend themselves economically to automatic telephony, and, if this proves to be the case, that quotations be also invited from the firms already mentioned for full automatic equipments for these four pressing centres.

(5, 6, and 7.) Development studies of Dunedin, Christchurch, and Auckland should, as suggested, be undertaken as soon as the engineering staff is sufficiently organized to cope with the work.

(8.) The Department must be prepared to enable its officers to keep pace with the growing intricacy and advanced electrical problems involved in modern telephony and telegraphy, by providing such electrical testing-apparatus as may be required from time to time.

(9.) Approved.

(10.) Approved.

(11.) This policy of having storage batteries instead of the much less economical and reliable primary batteries for telegraph systems at the larger centres should now be approved, and recommendations will subsequently be made as soon as data relating to the position shows the expenditure and economy involved.

(12.) A good deal has been done in this direction since I took office, and further recommendations will follow when suitably qualified entrants are available.

The alterations to the existing line plant at Wellington, estimated at £15,000, and the necessary buildings, estimated at £10,000 to £12,000, will subsequently have to be provided for, whatever system is adopted. I may here point out that the revenue derived from the telephone-exchange systems of the Dominion has increased from £21,552 in 1895 to £179,123 for last year. In addition to this, the revenue from toll communications, which is an adjunct of the exchange systems, was £64,811 for last year, an increase of 19·28 per cent. over the previous year. The income of the Wellington Exchange is now at the rate of about £29,000, and is increasing at some £2,000 per annum. At the present rate of increase the capacity of the switchboard now in use will be reached within two years. If a new outfit is not provided by the time the full capacity of the board has been reached we shall simply have to close down in so far as new business is concerned. As the manufacture and fitting up of a new switchboard with its millions of connections involves many months of constant labour, there is no time to waste. Similar conditions apply to Auckland, and in a somewhat lesser degree to Christchurch and Dunedin. It will therefore be necessary to order a plant for Wellington and Auckland this year, and for Christchurch and Dunedin next year, otherwise the Department will be in the position of having to refuse new business at those centres in a couple of years or so.

The Secretary, General Post Office, Wellington. J. ORCHISTON.

The CHIEF ELECTRICIAN to the SECRETARY, General Post Office, Wellington.

(Memorandum). General Post Office, Wellington, 18th June, 1912.

THE following is a synopsis of the recommendations contained in my general report made in connection with matters inquired into in the United States, Great Britain, and Europe during my recent mission abroad on behalf of the Department.

(1.) That the more extended use of the telephone generally should be promoted as far as possible The development of the telephone in centres of population in the Dominion as compared with that in many other parts of the world is low.

(2.) That the full automatic system of giving telephone service be adopted for Auckland, Christchurch, Dunedin, and Wellington.

(3.) That the full automatic system be adopted also for any exchanges at smaller places that may be requiring new equipment—in all cases where after a study of the conditions it may be found that the operation and economic features and the general advantage to the public in respect of the character of the service given would justify it.

(4.) That the Western Electric Company, London; Messrs. Siemens Bros., London, who supply the Siemens-Halske system; and the Automatic Electric Company, Chicago, who supply the Strowger system, be invited to tender for a full automatic equipment for Wellington.

(5.) That studies be made of the four large cities to obtain some idea of what may be the expected development in each—whether it is likely that it will be general throughout an area or more congested in particular parts of the area, and whether any particular parts will be specially difficult and therefore expensive to reach.

(6.) That the question of multi-office or satellite exchanges for the larger places be considered in their economic aspect as compared with giving service from, say, two or three exchanges in the area.

(7.) That, as development must to a large extent depend upon rates, the rate question be considered after the development has been considered, so that if necessary a scale of rates may be drawn up that will promote development, be a reasonable charge for the area available, and provide reasonably for interest and depreciation of the plant and apparatus.

(8.) That suitable appliances be obtained for determining the effect upon speech of apparatus that must be introduced into telephone circuits, and for enabling the results that may be expected from combinations of circuits which introduce varied kinds and quantities of apparatus to be definitely known.

(9.) That negotiations be opened with the representatives in the United States of the Wright and of the Morkrum typewriter telegraph apparatus to judge of their suitability for our conditions. These instruments are leased in the United States; they are not sold.

(10.) That quadruple Baudot apparatus be considered for use on the main circuits of the Department throughout the Dominion, and that two sets each for Auckland and Wellington be obtained for use over the circuits between those cities. The cost will be about £1,400 for apparatus.

(11.) That accumulators be installed for line batteries at the four large centres and a few other places where large numbers of primary cells are now in use. This would be more economical than present methods, and would improve working considerably.

(12.) That the technical staff be increased as may be necessary to give effect to the foregoing and to cope with expected developments.

Referring to the application of full automatics to Wellington as compared with common battery manual apparatus, the cost of equipment would work out about as follows. The approximate annual saving in operating-expenses by the use of automatics over the present system is estimated at £2,000, and over the more modern system of common battery at £1,500. These represent a capital cost of £50,000 and £37,000 respectively. There will be a further saving by the reduced quantity of copper necessary.

Automatics: It would be necessary to install about 5,700, so as to take care of existing main lines, extension telephones, and private branch exchanges. These would be in a main exchange, a branch exchange, and a few sub-exchanges as, after consideration of the area, would be found advisable. The American company can supply apparatus for extensions to switchboards within a couple of months, so that much stand-by equipment would not be necessary. The cost installed would be, approximately—5,700 at £6, £34,200; 5,700 dials at £1 1s. each, £5,985: total, £40,183.

Manual common battery: It would be necessary to install about 6,000 lines, as this system takes longer time to get extra plant and to get it fitted into service. Extensions and private-branch-exchange equipment being considered, the cost per line fully installed and ready for use would be approximately £4 a line: 6,000 at £4, £24,000.

Buildings would be required to accommodate the switchboard and for general telephone purposes whichever system was adopted, at a cost of about £10,000.

There is at present a good deal of aerial cable in Wellington. This is more subject to injury than if it were underground, and the maintenance of overhead cable or telephone plant of any kind is greater than that of underground. It will be necessary to make considerable additions to the underground to reach the site of a new principal exchange that will be necessary, and other deviations and additions will be required to reach any second exchange which would have to be considered if manual were adopted. If automatics were adopted the underground would be expected to be less extensive, but there would be several deviations (which might or might not be underground) from existing routes called for to lead subscribers to the sites of whatever exchanges may be decided upon.

It would probably be convenient and economical to make any additions to underground work at the time that alterations and deviations may have to be undertaken in connection with the connecting-in of subscribers to the new equipments. The cost of these works cannot be more than approximated at present, as these several sites are not determined, but it may be taken as not less than £15,000.

New telephones would be required for any new system, but as these would release the whole of the telephones now in use in Wellington, which could be used elsewhere, the cost of them need not be considered.

These considerations deal only with *first* cost. The annual charges and economic features have been dealt with in the general report, which should be consulted.

The Secretary, General Post Office, Wellington. T. Buckley.

REPORT.

The CHIEF ELECTRICIAN to the SECRETARY, General Post Office, Wellington.

SIR,— Wellington, 4th May, 1912.

In accordance with your instructions to me to proceed to the United States, Great Britain, and the Continent of Europe to inquire into matters relating to telephones (both manual and automatic), to systems of telegraphy, and to wireless telegraphy, departure was made by the s.s. "Maitai" from Auckland for the United States on the 11th March, 1911. San Francisco was reached on the 31st March after an uneventful voyage.

Some time was spent in San Francisco investigating the various subjects. As is well known, the severe earthquake which occurred in that city a few years ago was immediately followed by a great fire which raged over an area of some square miles of the city; and in common with everything else the telephone systems suffered severely, necessitating their being rebuilt. As the rebuilding was so recent, opportunity was afforded for advantage to be taken for the introduction in the case of the manual exchanges of the most recent developments so far as these were considered to be applicable to the present and prospective requirements; and San Francisco has to-day types of manual equipment and methods of operating in its telephone exchanges that are of a high order and worthy of study. Automatic telephones have also been introduced into the city.

It will be convenient to refer to the subjects that are being dealt with in the following order:—

(1.) Automatic and semi-automatic telephony;
(2.) Manual telephony;
(3.) General telegraphy;
(4.) Wireless telegraphy.

AUTOMATIC AND SEMI-AUTOMATIC TELEPHONY.

Automatic exchange working has attracted inventors for probably a quarter of a century, and from time to time different kinds of apparatus have been evolved.

Designers of full-automatic and semi-automatic systems all aim to reduce the working-costs of telephone service by introducing mechanisms that will enable the force of operators at the exchange to be either wholly or partially dispensed with, and that can be placed if needed at various points in a telephone area, thereby reducing the first cost and the maintenance cost of the plant, such as conduit, underground, and overhead cables.

The designers of full-automatic systems claim that there can be and have been produced systems the mechanism of which is so reliable as to give satisfactory service. The operator is dispensed with, and it is possible for any subscriber in any one of several exchanges in a given extended area to effect for himself telephonic connection with any other subscriber in any of the exchanges in the area.

The designers of semi-automatic systems contend that, considering the state of the telephonic art as developed along manual lines, it is not desirable that subscribers should be called upon to do their own operating. They claim that subscribers have become so accustomed to have access to an operator to effect connection for them and to whom to refer when anything appears to go wrong with a connection that it is not judicious in the interests of good service and of having a satisfied user to require the subscriber to do his own operating. The designers have every faith in mechanism properly constructed and cared for being entirely satisfactory to automatically effect the different combinations necessary to complete a connection, but they give the subscriber access to an operator who sets the automatic mechanism in operation.

The differences between these systems will become apparent as they are being described.

The extent to which automatic exchanges have come into use in America, and the rapid strides that have been made with them in that country during the last two or three years, have attracted the notice of telephone engineers generally. So much is this the case that certain of the Canadian Provincial Governments, the German and the Bavarian Administrations have adopted the full-automatic system on a considerable scale, while the British Post Office is erecting two or three small installations, and purposes one or two large installations quite shortly. The Commonwealth also is erecting an installation of full Strowger automatics at Geelong in Victoria.

Several manufacturing companies in the United States were seen to be engaged either in introducing into actual service or in developing full-automatic or semi-automatic equipment.

In addition to the Strowger full-automatic system manufactured by the Automatic Electric Company, Chicago, which system has been in operation for many years, and which, by reason of its merits and more extensive use in recent years, has brought automatic telephony into the prominence that it now commands, it was found that the following companies had systems either developed or in course of development: (1) The Western Electric Company, New York; (2) the North Electric Company, Cleveland; (3) the Stromberg-Carlson Company, Rochester; (4) the Keelogg Telephone Company, Chicago.

In Europe the Siemens-Halske Company, which has obtained the right to use in Germany the Strowger patents of the Automatic Electric Company, is actively engaged in the manufacture and supply of considerable quantities of equipment to the German and Bavarian Administrations. The Thompson-Houston Company in France has obtained the right to use the same patent in that country, and is engaged in the work of supply, but not to any considerable extent.

In Great Britain Siemens Bros., London, are erecting, at a cost of about £100,000, extensive works at Woolwich for the manufacture and supply of telephone appliances, special attention being devoted to the manufacturing requirements of automatic apparatus. About four months ago a company was formed in London, styled the "Automatic Telephone Manufacturing Company (Limited)," with a capital of £1,000,000, of which about £300,000 is subscribed, and about £260,000 taken by two companies as payment or part-payment for rights and works required. This company has purchased the Strowger patent rights from the Automatic Electric Company, Chicago, to manufacture automatic telephone apparatus for Great Britain and certain British colonies. A dividend of 6 per cent. has been guaranteed on £200,000 of preferential shares.

In Italy there has recently been completed an inquiry into general telephone methods, and a report issued. From a *résumé* of certain features of the report it appears that an investigation was made of some of the automatic exchanges installed on the Continent. The Commission speaks approvingly of the automatic and semi-automatic systems, recognizes their advantages in many respects, expresses an inclination towards semi-automatic because of the vivacious temperament and somewhat low standard of education of the Italian people, and states that some extensions should be made in large towns, leaving the subscriber to choose between the two methods. The Commission does not hesitate to recommend making some considerable automatic installations to avoid falling behind other countries, but regards as indeterminate the claims of net operating economy.

Besides the six systems enumerated there are—the Lorimer system, in operation at Brantford and Peterborough, and in construction at Lindsay, in Ontario; the American Automatic Company's system, whose factory is at Urbana, Ohio; the Dietl and Barth system (a modification of the Strowger system), in operation in Austria; the Betulander system, which belongs to Sweden.

This enumeration of systems, the activities of the different companies interested in their adoption in actual service, and the increasing favour with which operating companies and administrations are regarding them, as evidenced by their growing willingness to adopt them, may be accepted as indications that many telephone engineers, as already stated, are giving close attention to the claims made on behalf of automatics that they offer a considerable relief—some go so far as to say a complete answer—to most of the troubles that are incidental to the conduct of telephone-exchange service by manual methods.

There are about 8,250,000 telephones in use in America, and of these about 300,000, or about 4 per cent., are automatic; and it is a noticeable feature that they are in use only in the telephone exchanges of the "Independent" Companies. It should be understood that telephone service in America is being supplied, broadly speaking, from two sources, between whom there has been for years keen rivalry and perhaps not always the most agreeable business relations. These sources are (1) the Associated Bell Companies and (2) the "Independent" Companies. For years the Bell Companies gave such service throughout the States as seemed to them sufficient, but on the expiry, about 1895, of the principal telephone patents there sprang into existence keen competition, which developed into what became styled "the Independent movement." This movement is generally understood to have been the outcome of a desire to increase the use of the telephone and to improve the service. How far these aims have been attained may be gathered from the fact that in 1901 the Associated Companies had about 650,000 telephones, while to-day they claim over 5,000,000 and the "Independents" 4,000,000 telephones in use. This remarkable growth has been attributed to more than one cause. Some declare that it has been effected chiefly by the introduction of the measured rate of charging for service, and others that it is mainly the outcome of lively competition exerted, on the one hand, to obtain that development that seemed to be essential to general business well-being, and to give promise of being a good business undertaking; and exerted, on the other hand, the way and the need being shown, to maintain that superior position to which claim had been made and which was vigorously threatened. It is not necessary to the matter before me to discuss the merits or demerits of these declarations further than to say that even competition seems not to have effected for the public what they appear to consider desirable, as for some time the aid of Public Utility Commissions has been introduced or invoked to lessen the burden of costs and rates that the public in some places appear to regard themselves as having to endure.

The common-battery system was well established in 1903 as a suitable system for giving satisfactory telephone-exchange service and as being a big advance on the magneto system both in economy and grade of service rendered. Development was taking place rapidly by means of this system. It was about this time that automatic telephone-exchange equipment began to be offered with any hope of considerable adoption. First cost, dread of excessive maintenance, and the lack of extended trial of any automatic system combined to cause automatics to have few friends. Despite this, even as early as 1901 two installations of Strowger automatics were put in at Fall River and New Bedford, and worked well. About 1903, Grand Rapids, Michigan, operating a magneto-board, decided to adopt automatics, and it was about the same time that Dayton, Ohio, similarly decided. These systems have continued operating with success and satisfaction to the subscribers and the operating companies. From those early beginnings the use of automatics, mostly Strowger, has gone on increasing until there are now about 300,000 lines operating in about ninety different cities. This development of mechanism for automatically effecting telephone service took place entirely in the "Independent" field, and as each operating company was a separate and uncontrolled unit so far as its own affairs were concerned, and had its field of operations confined to a comparatively limited area, it was practicable for any company to give consideration to any proposal for the supply of special equipment that offered features conducing to economy and prompt and satisfactory service.

The Associated Bell Companies, on the other hand, being all interrelated and subject in a considerable degree to the central control of the American Telegraph and Telephone Company, were held to the use, in the main, of those systems, the magneto and central battery, principally the latter,

that were in most general use and considered to be standard. Any deviation from the use of standard methods could only be exercised with the greatest caution where such vast interests were concerned, and it was therefore necessary to review carefully what would be the effect of any change upon the whole commercial, economic, and engineering aspects of the Associated Companies' affairs. The responsible officers had further to consider whether any system of automatics extant had attained that degree of perfection in operation and freedom from growing quickly obsolete by more improved methods being devised that would warrant the displacing by such system of the common-battery system that was meeting so efficiently general telephonic requirements. There was also always the patent situation to consider, and companies in such active rivalry were not to be expected to proclaim that there was merit in the equipment of their rivals. With the weight of so powerful an organization opposed to existing automatics and manufacturing companies, both manual and automatic, of the "Independent" interests competing with each other for business in the "Independent" field, the 4-per-cent. development of automatics, so far from being insignificant, is rather to be regarded as a testimony of the merits of that system.

Three hundred thousand automatic telephones in America are about half the number of telephones in use in the British Islands, and there are to-day more automatic telephones in use in *each* of two cities, Los Angelos and Chicago, than there are telephones operating in the whole of this Dominion. This development in automatics has come about in the last few years, due, no doubt, to improvements introduced, such as the use of common battery at central points, the use of the two wires instead of what was called the three-wire system, and the party-line private branch exchange, metering, automatic ringing, and other facilities afforded.

It is now conceded by almost all telephone engineers that automatic and semi-automatic apparatus can be obtained that will work exceedingly well, and that will perform satisfactorily under the manipulative guidance of the subscriber or of the centrally situated operator the functions of effecting connections for telephonic intercommunication. The controversial question that invariably arises is, will it do so economically as compared with manual when questions of first cost of plant, maintenance of plant, depreciation, and the need of mechanics to keep the apparatus in order are considered. In the matter of full automatic the question also arises, in countries where it has not been in operation, whether the public will take kindly to effecting their own connections by manipulating a dial. The question of the economy will be dealt with at a later stage. So far as the manipulation is concerned, in my opinion, based upon inquiry and upon what has been observed, that feature need not be looked upon as an objection at all. People in the States seem rather to like to work the dial. In Munich, on the first introduction of the automatic there about two years ago, fully 60 per cent. of the people expressed dislike to the system; they soon became pleased with it, and now not 2 per cent. of them have any objection. There are about 5,000 automatic subscribers.

The American Telephone and Telegraph Company, despite its attitude already referred to towards automatics, began itself the study of a full automatic system in 1900, and took up the study of semi-automatic systems in 1904. From the latter year to the present time it has had a large force of engineers and mechanics engaged in developing a satisfactory system at heavy expense. This company, from the studies so far made, appears to be satisfied that it can produce apparatus that, operated as a semi-automatic system, will give both satisfactory and economic telephone service under the exacting conditions that are peculiar to complex rates and classes of service that have grown up in the principal cities of the United States, which are amongst the most populous in the world and possess a business intricacy second to none. They estimate that the application of semi-automatic methods to the whole of their exchanges in the States would result in very considerable annual savings. The Western Electric Company, which is the manufacturing company for the American Telephone and Telegraph Company, has devised the semi-automatic system referred to, which is also suitable for full automatic, and has had it in operation in a 450-line board in its factory for about eighteen months. The system is giving the best of satisfaction operating as an exchange of New York City telephone-area. The American Telephone and Telegraph Company is not satisfied that *for its conditions*, which are largely those of providing telephone service in great cities, the full automatic can be made sufficiently flexible to be acceptable to the subscribers. They therefore hesitate about equipping telephones with dials to enable the subscriber to set up his own connections, fearing that under the circumstances peculiar to large cities the attempt would not meet with success. The experience derived from those places where full automatic is in operation in moderately large cities does not seem to support that view. Subscribers appear to like making their own connections, and have not at any time urged to me any objection on that score. Generally they prefer automatic service, and commend the features that you get through to your subscriber quickly; that you hear the bell ringing when the dial movements are completed; that you know any delay in answering is due to the called subscriber, which really speeds up the service, as subscribers answer more promptly; that there is no girl "butting" in on the line, as they express it; that if your subscriber is engaged you get the "busy" signal at once; that ringing is continuous until the answer is given, and that any connection can be broken instantly at any stage by merely depressing the lever and a new call sent in immediately.

The objection of the American Telephone and Telegraph Company, however, while applying in some measure to the manipulative feature of the dial, has more particular reference to an opinion entertained by the engineers—that the public like to have access to an operator who can give special attention when irregularities arise (and a certain percentage do arise) and so help through connections. There have also grown up around the manual system in large cities many different ways of giving service and of charging for it, and many privileges that some subscribers by paying avail themselves of and that others do not take, all of which are indicated by various bars and marks on the opals and other switchboard parts, and have to be looked out for by operators. Semi-automatic under these

circumstances calls for no alteration, whereas full automatic would probably give rise to much confusion and oblige an entire review of the whole system of charges, which might have far-reaching consequences.

It must be understood that even with full automatic installed attendants may not entirely be eliminated. In large and even moderate-sized places where there are private branch exchanges it is necessary to have operators for the conduct of that class of business. In large hotels in the States there are usually telephones in every bedroom. The occupants of these are continually changing, and it would be impracticable for subscribers to seek such occupants automatically, as they would not know what number to call up. That class of work is usually taken care of by placing a girl at a manual switchboard. She is provided with a list, which is corrected from hour to hour or day to day, of the different occupants, and on any call coming in for any of these persons she can, of course, easily connect the caller to the right person.

Pay-stations, farmers' lines, and toll circuits require to be worked by an attendant similar to private branch exchanges. This is the method that is adopted at present for working those classes of service when associated with general manual operation. It would be quite practicable for the occupants of bedrooms to " ring out " automatically.

Toll circuits have been arranged so that the originating exchange, after having provided for charges, can ring direct to automatic subscribers at a distant exchange without any attendant at that exchange being required to handle the call. This saves half the attendant labour.

In large warehouses it is practicable to do the private branch exchange work manually, as hitherto, or to install automatics, as with the latter you can " ring out " from or " ring in " to any branch. To get particular persons in a branch is not usually so necessary. If there was much demand for that class of service manual would probably be found most suitable. There are other features that will be brought out when some of the automatic exchanges are being specially referred to.

The engineers of the British Post Office are giving close attention to the progress of automatic telephone systems, and are confident that some form of automatic mechanism will engraft itself on telephone practice as a permanent feature.

It is generally considered in America amongst automatic engineers that about 500 lines is the minimum number for which it would be economical to introduce automatics.

The German Post Office favours full automatics, and has several exchanges working which will be enumerated later. It considers that for small exchanges, up to, say, 200 subscribers, where an all-night service is required, it is more economical to install automatic than manual, because with the latter attendants are necessary both day and night. For larger exchanges, from about 3,500 subscribers upwards, again that office favours automatics as being more economical. The intermediate-size exchanges, at the prices it has paid, are considered to be more economical if handled manually. Apparently the prices to the German Post Office have been very high. It cannot introduce automatics at present into Berlin and some other large cities until the law is changed. Subscribers, as the law stands, have several alternative ways of getting and paying for service, and may change from one way and rate to another frequently. This is unsatisfactory, and until altered the Post Office says it would be impracticable to introduce automatics. There was talk of an effort to get an Act passed to meet the difficulty, but it was doubted if the attempt would be made until a following year.

At Munich, in Bavaria, there are two full automatic exchanges of 3,000 and 2,000 lines working well. The cost of these per line was stated to have been very high. The system used there, and wherever automatics have been installed in Germany, is the Siemens-Halske, which is the Strowger system modified. There is reason to believe that the price paid for automatics per line throughout Germany has not been lower than for the Munich exchanges. It is thus explained how the German Administration does not appear to find economy in automatic exchanges intermediate in size between those of 200 and 3,500 lines. The engineers at Munich stated that they expected in 1917 to have 45,000 automatic telephones in operation, and to be effecting a saving of 1,000,000 marks or £50,000 per annum as compared with operating by manual methods. There is no question at all with them of the suitability of automatics for giving telephone service.

Approximate prices quoted to me for this system of automatics show that it is very much cheaper now. In Austria, in the Graz Exchange, there are 1,500 full automatic lines. These are stated to have cost fully three times what such equipments can be obtained for to-day. At such a capital cost as this and that said to have been paid in Germany, it seems incredible that if economic considerations were at all regarded any automatic installations could have been undertaken. It is, however, the intention to equip Vienna with automatics which will run into at least 20,000 lines. It is stated that this is for the purpose of dispensing with girls, and that the telephonic development of other parts of the Empire will be backward as a consequence. Some explanation of the situation appears, however, when it is stated that the manual practice has been to allow $3\frac{1}{3}$ operators to each position. As each operator is paid about £37 10s. a year this amounts to £125 per position per annum. With this has to be considered the fact that the women remain long in the service and are entitled to pensions, so that it is not surprising that relief is sought from such a situation even by the use of high-priced automatics.

In Germany the position is much the same as in Austria so far as length of service and pensions of women are concerned, consequently in the former country, too, there is a special incentive to use automatics. It may be expected that in Germany the prices for further installations of automatics and for additions to existing installations will be much lower than have prevailed hitherto.

In observing automatic exchanges in all places where they were met with on my travels, the striking feature was the limited number of persons that were engaged on them as compared with the numbers in evidence, principally, of course, as operators, in manual exchanges. Several automatic exchanges were quite unattended, and the quality of the service that was being given was such as was

satisfactory to the user, who did not appear to have any desire to quit and go over to the manual company, nor had the automatic operating company any fears that service rendered in that way was going to be prejudicial to the retention of their subscribers.

It should be explained that in moderate-sized and large cities where telephone service is given manually there are usually several exchanges, and the subscribers to these require to intercommunicate. This necessitates two classes of switchboard in each office called the A and the B board. The A board receives the subscribers local to each exchange. The B board receives the *incoming* calls from any A exchange, and the B operator has to complete such calls to the subscribers local to the exchange called into. This the B operator does through the multiple. There are usually half as many B as A positions, so that half as many B as A operators are required. Of course, where there are not many exchanges in an area, and whatever are are small, this relation of numbers does not hold, but for the present purpose let it be considered so.

The use of semi-automatic dispenses with all those B operators, with all the apparatus at B positions, and saves the floor-space they have been taking up. It does more, because it has been found that a large proportion of the errors that take place on manual switchboards occur between the A and the B operators, and these cannot now happen. The A positions working semi-automatic do not require the multiple of the subscribers, and the high cost of that is effaced. That saving, however, is only possible in cases where the multiple has been on the A board, and in large places where trunking of calls is in excess of 75 per cent. the multiple is placed only on the B boards and all calls are trunked. The A operators, semi-automatic, have only one cord, and it has been found that while on the manual the number of straight-line calls that can be properly taken care of is about 230 per hour, the capacity of an operator is increased to about 350 calls, so that the number of A operators can also be largely reduced, say about 35 per cent. Some switchboard is still necessary, but it is much reduced and simplified. In the place of the more complex manual board, automatic machinery has been introduced. The A operator can be still further reduced by dispensing with the upright boards with cords and supervisory features, and in their place substituting flat boards, comparatively inexpensive and taking up but little space. Automatic mechanism is then introduced to distribute calls to any operator who may chance to be idle at the moment. This more evenly divides the work, and it is found that an operator can take care of 450 to 500 calls per hour by these means.

From the preceding considerations it can be seen how telephone authorities in large areas with multi-offices may figure that it is economical to install semi-automatic, and thereby retain certain features of control and of the operator keeping in touch with the subscriber that under certain conditions are considered by some operating companies as indispensable. It is worth while noticing how far such considerations would be applicable to our New Zealand conditions. So far we have only single-office exchanges, therefore no B boards. If we were to adhere to manual switchboards the time has probably arrived when it will be imperative to have another or other exchanges in each of our four large centres. This would, of course, bring along B boards at all such exchanges. They would not, however, be very extensive for some time to come, but whatever may be their size it is desirable to avoid them if at all practicable. There being no B boards, semi-automatic would not effect there any reduction of operators, apparatus, or floor-space, except the prospective reduction referred to in the preceding sentence. It is only on the A boards that reduction of operators, apparatus, and floor-space could be looked for. Dealing, therefore, with the semi-automatic method that distributes to the idle operator, which method requires fewer operators and less apparatus and floor-space than the other method using cords and supervisory control, the situation works out about as follows:—

Assume a single-office exchange of 6,000 subscribers and a calling-rate per day per subscriber of 8, the number of calls in the "busy" hour one-eighth of the total daily number, there are then 6,000 calls coming in the busy hour. In common-battery exchanges operators are expected to be able to make 230 *straight-line* connections per hour on the basis of being only thirty minutes occupied in the hour. Some companies place this at 250, and it came under my notice in two or three places that 275 were required; 230 seems reasonable. Various considerations operate to increase the value of each call, so that having regard to the future it is probably fair to recokon 190 actual calls as equivalent to these 230 straight-line calls. This would require about 32 or 33 positions. Taking 1·75 as the multiplier per position to arrive at the number of operators required for the twenty-four hours, and to provide for relief and sickness, there would be needed, say, 56 operators, 4 monitors, and 2 supervisors, at a cost of about £4,520, plus 2 information and complaint clerks, and 1 observation clerk—say, 3 at a total of £260 = £4,780 per annum. Toll-board operators are not being considered, and distinction has been made between the cost of men at night as compared with women. By the semi-automatic method of distributing to the idle operator, as each operator can handle 450 calls, to take care of 6,000 calls 13 operators would be required in the busy hour, say another 6 to provide for relief, sickness, and hours not covered by those of the 13 operators, and 3 for night-work. (It is to be noted that night-work can be more easily cared for by this method than by manual, as the operator does not need to move about: she remains seated, and the calls seek the position.) Total, 22 operators, 2 monitors, and 1 supervisor; cost, £1,920, plus £160 for 2 information and complaint clerks = £2,080. Operators are taken at an average of £70 per annum, monitors £110, and supervisors £160. The other semi-automatic method, with the cord and supervisory features, would work out higher for operators, and would require more apparatus and floor-space besides.

Semi-automatic and full-automatic systems, so far as the automatic mechanism is concerned, are practically the same. The operator is provided with a keyboard in the first case to enable her to start automatic appliances that in the other case the subscriber starts by means of a dial, or set of levers, or as may be otherwise suitably arranged.

It has been shown that the semi-automatic costs £2,080 per annum, plus extra appliances and floor-space. These have now to be compared with the costs for full automatics. At the subscriber's telephone in full automatic there is a dial which costs £1, or £6,000 for 6,000 subscribers. This may conservatively be given a life of about eight years, or, say, 12 per cent. depreciation, and there is interest to be reckoned at 4 per cent. The cost of maintenance of the dial in exchanges that were visited was said not to be of consequence. The Automatic Electric Company, of Chicago, states that from a record kept for a considerable period at four exchanges the dial maintenance cost did not exceed 8½d. each per annum. That we may be certain this maintenance is not being considered at too low a figure, it will be introducing a desirable margin to take it at 1s. per dial per annum. This makes £300 for the 6,000, which is practically equivalent to setting aside two men to attend to dials only. Summarizing, we get—Dials: Maintenance, £300; depreciation and interest, 16 per cent. on £6,000, £960: total annual charge for dials, £1,260. Full automatic should also bear an additional charge of £160 per annum for two extra information and complaint clerks—total £1,420, as compared with £2,080 annual charges for semi-automatic, which also requires much more floor-space. These sums do not include the cost of maintaining and keeping in order the central-station mechanism, which is the same for both. That is dealt with later.

This shows that from economic considerations semi-automatic switchboards, *under New Zealand conditions*, do not "prove in" against full automatic, and judgment has now to be formed between full automatic and manual. It should be carefully noticed that the comparisons that have been made so far between semi-automatics and manually operated switchboards have *not* been made with manual boards of the type that we are at present operating, but with the most approved type of manual common-battery board that can be obtained. Had the comparison been made with our present types of magneto-board and equipment generally, it would have been necessary to charge many more operators against the manual board than have been charged.

It is proper in reviewing systems the use of which may be contemplated to compare the most approved of one type with the most approved of another type, and this will now be done as between full automatics and manual common battery. It is assumed that the exchange is a single office. This assumption leaves the outside work in both systems the same, and thus avoids complication. The number of lines and telephones is taken as 6,000, with an ultimate capacity of 10,000 and a calling-rate of 8 per subscriber per day. The first cost of such a manual switchboard would be, approximately, 6,000 lines at £3 10s. each = £21,000, plus £4,000 for installing = £25,000. The first cost of full-automatic central-exchange apparatus would be for 6,000 lines at £5 = £30,000, plus £4,000 for installing = £34,000. At the subscriber's telephone there would also be required a dial costing £1, making an additional amount of £6,000.

The annual charges for the manual exchange would be—

	£
Interest 4 per cent., depreciation 8 per cent. = 12 per cent. on £25,000	3,000
1 manager	300
1 wire-chief	220
1 assistant wire-chief	160
2 distributing-frame men at £150	300
2 trouble or switchboard men (inside) at £170	340
1 information clerk at £80	80
1 complaint clerk at £80	80
1 observation clerk	100
56 operators at £70	3,920
4 monitors at £110	440
2 supervisors at £160	320
	£9,260

Annual charges for automatic:—

	£
Interest 4 per cent., depreciation 6½ per cent. = 10½ per cent. on £34,000	3,570
1 manager	300
4 {information clerks at £80 / complaint clerks at £80}	320
1 switchboard foreman	250
1 wire-chief	220
1 wire-chief assistant	160
2 distributing-frame men at £150	300
8 trouble attendants (inside) at £170	1,360
Extra for interest, depreciation and maintenance of dials at subscribers' stations, particulars already shown	1,260
	£7,740

The difference in favour of automatics is £1,520. If the depreciation on automatics be taken the same as manual—*i.e.*, 8 per cent., instead of 6½ per cent.—the difference mentioned would be reduced by £510 to £1,010.

Another way of viewing the matter is that it would be necessary for the first cost of manual common-battery equipment not to exceed about £1 8s. 9d. a line to cause the *annual* charges in both systems to about balance. For 6,000 lines at £1 8s. 9d. first cost = £8,627, plus £4,000 for installing = £12,627. This at 12 per cent. per annum = £1,512. This will reduce the annual charges shown for manual by £1,488, or from £9,260 to £7,772, which is in close agreement with £7,740, the worked-out annual charges for automatics, and this would be more marked in an exchange

of a larger size. With the automatic depreciation taken at 8 per cent., instead of 6½ per cent., the first cost of manual at £2 2s. per line would about enable annual charges on both systems to balance. The maintenance is taken as the same on both systems, but should be less on the automatic. If automatic were used there would be a toll-board required at a capital cost of about £1,200, bearing interest and depreciation charges of 12 per cent. = £144 annual charges. The outside plant, subscribers' instruments, and the number of outside-trouble men required would be the same in both systems. The outside lines would require to be maintained in good order, as common battery would be used with both. In the study just made the depreciation on manual has been taken as slightly higher than that on automatics, because, judging by the attitude of engineers, it may be considered that manual common-battery switchboards will have an increasing percentage of obsolescence. The dials for the automatic have been heavily depreciated for the same reason.

Both manual and automatic switchboards have a longer physical life than that calculated upon, but such a study has to be made on a conservative basis. It should be remembered that as the manual board is added to, the cost per line increases, whereas it is practically unchanged in the automatic. Increased calling-rate per subscriber increases the cost of both, as more positions and operators are then required in the case of the manual, and more switches in connection with automatics.

It will be interesting to see how manual common battery and automatics work out in respect of annual charges for exchanges as small as those consisting of 500 lines. For manual the cost per line would be about £3 = £1,500, plus £300 for installing, or, say, £1,800.

Annual Charges.	£
Interest 4 per cent., depreciation 8 per cent. = 12 per cent. on £1,800	216
1 wire-chief and frameman	180
7 operators at £70, for supervision day, evening, and toll work	490
	£886

For automatics the cost per line would be £5 = £2,500, plus £300 for installing = £2,800.

Annual Charges.	£
Interest 4 per cent., depreciation 8 per cent. = 12 per cent. on £2,800	336
1 switchman	200
2 toll operators at £80	160
1 information and complaint clerk at £80	80
Also 500 dials at £1 = £500.	
Interest 4 per cent., depreciation 12 per cent. = 16 per cent. on £500 = £80	
Maintenance of dials at 1s. each = 25	
—	105
Total	£881

A toll-board would be required for either system, at a cost of about £100, with increased annual charges the same for both systems—probably £30. A learner would be required at these small places if automatics were to be only in small places, so as to provide for times of illness, absence, holidays, &c., of the switchman. As, however, automatics, if placed at small offices, would also be used at large offices where learners would be available, a relief could always be afforded a small office without keeping a permanent second man attached.

Maintenance of these small exchanges is taken as being the same, and the plant, subscribers' telephones, and number of outside-trouble men would be alike.

Were the comparison made with magneto-manual it would appear in a less favourable light.

The suggestion conveyed by this study is that automatics could be used for exchanges as small as those of 500 lines. There would be practically no monetary advantage, but there would be no loss as compared with manual common battery, and as the subscribers increased some saving would be expected to follow. There would be available then in these small exchanges the advantages that have been earlier referred to as resulting from the use of automatics. Night service would be no extra cost.

Where there are two or more manual exchanges in a city, as compared with a single exchange, there is an increased advantage to be got from the use of automatic, because all of these manual exchanges require more operators and more apparatus. The subscribers require more positions, as each operator cannot attend to so many calls when a proportion of them has to be made through a second operator at a junction position. The junction or B positions, with space for them and operators, also have to be provided. Under these circumstances no saving in outside plant is to be looked for from automatics as compared with manual, as only a certain proportion of connecting lines or junctions are required, and they are about the same for both systems.

It is usually claimed for the automatic system that besides the two, or three, or perhaps more principal exchanges, according to the size of the city, that will take care of the greater number of the subscribers, smaller satellite exchanges may be placed here and there to provide for subscribers further out, and this is sometimes done. Los Angeles and Columbus, in the United States, have several such satellites. In one of the cities where automatics were in use the engineer informed me that to serve from central between 650 and 700 subscribers at a distance of about three miles would have cost £9,600, whereas the service by a satellite exchange cost £5,600 with about the same annual charges in either case. The suitability of satellites, however, needs to be carefully considered in each

case. A building has to be provided; it need not be large. The satellite Wiltshire, which is a sub of West Branch exchange, Los Angeles, is a brick building 20 ft. by 20 ft. It provides for 500 subscribers, and has room for about 700 more. The building must be maintained, must provide for circulation of air, provision must be made for heating and lighting, and for supervising from the main exchange. The apparatus must be kept in order by a visiting switchboard-man, and when anything is wrong it must be specially visited. If the satellite is not installed, a corresponding quantity of apparatus has to be maintained at the central office. The problem thus becomes one of balancing the annual cost of the satellite against the annual cost of the extra outside plant that would be required if it were not used. It is found that operating companies with experience of satellites are increasing them.

It may be of advantage at this stage to consider purely operating-costs for the three systems, magneto, common battery, and automatic. The questions of depreciation and interest will not be touched on, as the way these affect the annual charges has already been indicated.

In considering the magneto system the operating-charges for the Wellington Telephone Exchange will be set out. The operating-charges for common battery and full automatic must be estimated.

Wellington has about 3,800 lines and 1,200 extension telephones. The calling-rate is about 8 per day a line. The operating-expenses inside are, per annum :—

	£
1 manager	290
2 switchboard-men (inside)	346
2 test clerks	350
1 main-frame man	160
1 man repairing cords	140
66 operators (females) at £61 average	4,025
Night operators (men), 17 working half-time on S board	1,155
5 supervisors and monitors	720
	£7,186

For common battery manual with 3,800 lines and 1,200 extensions, calling-rate 8 a line a day, the operating-expenses per annum would be :—

	£
1 manager	290
2 switchboard-men (inside)	346
2 test clerks	350
1 main-frame man	160
1 man repairing cords	140
48 operators* at £70 for day and night work	3,360
5 supervisors and monitors	720
Observation clerk	100
	£5,466

* It is found that £70 is the average annual salary for operating the Wellington exchange, although the average salary of the cadettes is only £61. Toll operators are *not* included.

For automatics with the same number of lines and rate of calling we get, per annum :—

	£
1 manager	290
1 switchboard foreman	250
1 wire-chief	220
1 assistant wire-chief	160
1 main-frame man	170
6 switch or inside-trouble men at £170	1,020
4 information and complaint clerks at £80	320
	£2,430

The difference between magneto and common-battery operating-costs for the same work amounts under magneto conditions to £7,186 — £5,466 = £1,720 per annum in favour of common battery.

The capital cost of equipment for common battery, if both were being put in new, would be less than for such a magneto-board as is in use at Wellington, as considerably fewer sections would be required.

The automatic switchboard-operating or inside maintenance costs are much lower than the inside costs of the other two systems. The comparison between automatic and those systems cannot, however, be made on that basis alone, as the first cost of plant and the increased cost of telephones due to the dials have to be considered. Automatic has already been shown to possess an advantage in annual charges over common battery of about £1,500 per annum for 6,000 lines, or, say, £1,000 for 4,000 lines. Taking, therefore, £1,720 and £1,000, it would appear that full automatic equipment would possess an advantage for Wellington over *present* costs of operating of £2,720 per annum. As some of the factors to reach this conclusion have had to be estimated, and so that automatic advantages may not be unduly pressed, if the gain be taken at, say, £2,000 per annum that amount represents a very substantial consideration.

The toll work in Wellington is now performed by eleven operators, drawing £965 per annum. That has been left out of consideration in the preceding remarks, and would remain unaffected, as toll work must continue to be done manually.

The salient features of several automatic exchanges visited will now be set forth.

San Francisco has four automatic exchanges, all on the two-wire system—that is, there is no third circuit formed over these wires by using the earth. They have been working two years. There are 15,500 stations in San Francisco, and on the other side of the harbour, in Oaklands and Berkeley, there are about 11,000. There are several exchanges on the Oaklands side, all on the three-wire system. One system works into the other without difficulty. On Oaklands side there are two exchanges, each of 700 stations, attended to by one man, and with no person in attendance at night.

The main office in San Francisco is a handsome seven-story brick building, which cost £50,000. The switchboard is on the top floor, and is equipped for about 6,000 lines. About 4,000 are in use, serving 6,400 stations. This exchange is called C: the others are J, M, and S. The number of persons attending to these is set out below :—

Exchange.	Stations.	Foreman.	Switchmen.	Apprentices.	Tester and Wire-chief.	Complaint Clerk.	Outside trouble.
C	6,400	1	6	2	1	1	4
J	2,900	1	3	2	1	1	3, or 1½ each.
M	2,600	1	3	1	1	1	
S	3,500	1	3	2	1	1	2

There is an ordinance of the city by which wire-workers are to be paid 3·75 dollars, or 15s. 7d. a day. These men are so paid except the apprentices, who get 8s. 4d. to 10s. 6d. a day.

There is only one man on at night in any exchange, and but for the desire to have a man about the building there is no special need for that in J and M. It is obvious from the number of outside-trouble men, who attend to cable and line faults and the subscribers' telephones, that the latter do not give undue trouble even though they have the dial mechanism attached. Records showed the calls per week as ranging from 358,000 to 313,000, or about 3·5 per day per station.

On the sixth floor is a workshop, where there are about fifteen men. These are engaged principally in manufacturing and making up private branch exchange and apartment boards for use in subscribers' premises. Some of these apartment boards were visited, and the proprietors stated that they gave every satisfaction. One of these boards was left without a visit from any officer of the company for two months as an experiment, and there was no complaint in that time. The working of the switches in these apartments by the various arrangements made indicated the flexibility of the system to provide for varied classes of service.

Two other automatic exchanges were visited. They were equipped for about 4,000 lines, with about 2,700 stations each. The buildings were substantial, built of brick, and one story high. It was astonishing to find so few people about. There was a man at the distributing-frame, one at the test-table, one at the complaint-table, and three others for switch purposes in each office. One room was 55 ft. by 90 ft., and it was not nearly half-filled with the switches for the 4,000 lines. The ringing and charging machines, a gas-engine, and the light and charging power boards were in a fine basement. The secondary cells were also below. The voltage used for talking is 48. There is a special Weston relay which gives an alarm when the battery voltage is too low or too high. This enables back E.M.F. cells to be cut in or out of circuit at the proper time. There are lamps in various positions which glow when there is any trouble on the switches, and these serve as guides to attendants as to where trouble is to be looked for.

The Chinese are numerous subscribers to the automatic, as they can call their person without requiring to speak English to an operator.

Los Angeles (population 330,000) has the three-wire system. Some of the apparatus is seven years old and giving entire satisfaction. There is no trouble about wear of parts. Wipers, like plugs in a manual board, wear a little, but are easily renewed. They have Keith line-switches mounted circularly, and covers for them. The covers are for keeping out dust, but they are seldom used. Some Keith switches are mounted in square cabinets. This is found to be better, as all parts and connections are more easily accessible.

The equipment in this exchange (main) takes more room than the more recent exchanges, as when it began a first selector was required for each line. This is not so now, and first selectors are only about 10 per cent. of the number of lines, and Keith line-switches—one of which is required for each line—take quite little room as compared with first selectors.

The switches have lamps, bells, fuses, and other devises for denoting trouble and the part of the board it is in. Men are in attendance removing trouble and testing switches to obviate it. Some are good men, some apprentices. The latter watch for trouble: if they find any they cannot remedy they make out particulars on a paper and file it beside the row of switches. The good man then takes it up. It is claimed one good man can look after switches for 1,000 lines. The switch-room is 66 ft. by 75 ft., and there is equipment for 11,000 lines in it. There are 9,000 lines now operating with about 13,000 stations. The room will accommodate about 15,000 lines. This is about one-third of a square foot per line. A little over 0·4 of a square foot is more usually allowed.

When a subscriber thinks he has cause for complaint he rings up a number which takes him to the trouble-room, where there are four female clerks in the busy hours. He is told his trouble will be inquired into. The clerk makes out a ticket and passes it on to another girl, who tries to get the called person and also calls the person complaining. In 70 per cent. of the cases reported there is no real trouble, the difficulty being that the called person does not answer or is not in. Automatic

exchanges encourage subscribers to call up trouble department, and make liberal provision in that branch to take care of subscribers' complaints. At the main exchange 550 complaints a day are received from 13,000 stations. Some of these complaint clerks would be wanted in a manual exchange of corresponding size. In manual working the subscribers have access to an operator who informs them of many things that in an automatic they cannot know without reference to the trouble department. For some years in this city they were working several thousand manual C.B. subscribers and a very much larger number of automatic subscribers together. They found the automatic methods, although the subscribers were more scattered than the manual subscribers, to be much the more economic way to give service, and they gradually introduced automatics until all the manual subscribers were on that system. They still have private branch exchanges working manually, and they will probably continue to work them in that way. These private branch exchanges are supplied with current from the central exchange.

The information-desks for the whole city are in this exchange. There is only one board, and one girl who has before her eight sets of five jacks each. A few feet away is the information-table, fitted for eight girls. Each has a directory with the alterations made and generally such information as is likely to be asked for. Each girl has also lamps and jacks before her. There is also a large revolving square containing pigeon-holes, in which are cards containing particulars. The first girl distributes information-calls to the other eight; as she has the plugs she can see who is free, or most nearly so, to take another call. Each of the eight can turn the table and get access to the information there. This works well.

The information girls are reduced in number as the business requires. The calling-rate per subscriber per day is high—from 19 to 20.

In the private branch exchange in the main office there are 85 girls. There are 29 manual-board positions, and more are being added. There are fully 10,000 manual telephones in these private branch exchanges. The 29 positions are staffed from 8 a.m. to about 6 p.m.; thence to 9 p.m. alternate positions are vacant; after that there are 5 girls all night. All the subscribers to this exchange, both manual and automatic, are multiplied on its manual board. There are supervisors and monitors in the usual proportion. Here also is the three-position board to enable operators to complete calls to or from automatic or manual subscribers at a few of the smaller exchanges that have no operators.

The company is doing a great deal of its own manufacturing. It is making its own manual equipment. The company does not solicit business. It cannot erect plant to keep pace with demand for service, and is in need of capital. The area of supply extends out for about nine miles. The rate is—business £1 0s. 10d., and residence 8s. 4d., a month, flat rate, with no mileage charges. They would like £1 7s. business and 10s. 6d. residence rate per month, and are striving to get the city to permit that rate, but so far without success. They did not declare a dividend last year, but used the earnings for extensions. Although they do not solicit business, they gained 410 stations last April and 566 last March. The girls' pay averages £8 a month. Looking after the switches there are 6 good men at about 16s. a day; 4 men at 6s. 6d. a day (these watch and ticket trouble); 3 good men on at night at 16s. a day.

As an indication of the number of telephones in buildings, one outside man at 15s. 6d. a day looks after 3,000 telephones located in four buildings having 900, 800, 800, and 500 each. In two hotels that came under my notice—viz., the Alexandra and the Lankershim—there were 750 and 300 telephones respectively.

South office was visited. This is the oldest office, and it has still the oldest plant. There are 4,500 lines and about 5,100 stations. The number of men for the switch attention here is 12, to cover all hours, viz.: 3 at 15s. 6d., 14s. 6d., and 13s. 6d. a day; 2 at 13s. 6d. and 12s. 6d. a day; 7 apprentices, 1 at 11s. 4d., the others at 9s. 4d. each a day; 2 girls for private branch exchanges, 1 girl as clerk to wire-chief, and 1 complaint girl, all about 40 dollars a month; 1 wire-chief at 17s. 8d. a day; 3 trouble men for instruments and lines at 12s. 6d. a day, for outside work.

When men work on Sunday in any exchange they are paid time and a half. There are no girls on at night, and only one man.

Labour is expensive here and along the Pacific coast.

The average length of each line in the heart of the city is less than one mile, and in the residential part over two miles. There are thirteen automatic exchanges in Los Angeles, with lines ranging from 9,000 to 400.

West office was visited. Here, in a room 30 ft. by 87 ft., with space to spare, there are 4,500 lines and 5,100 stations. There is only one girl in attendance, and the same number of men as at South office.

Wiltshire is a small exchange in a brick building 20 ft. by 20 ft. It contains 500 subscribers, and will accommodate many more. It has been previously referred to.

Adams office was also visited. The building here is a very large fine brick structure, much too large for requirements, and admitted to be so. The company would like to have the money sunk in it available for extensions. This was erected before they were satisfied that it would be economical to give service from a number of points rather than from a limited number of fair-sized exchanges. There were only a few men here, as in the other exchanges visited. There were two girls, one for private branch exchanges and one for complaint. This office contains the old-type apparatus, or a first selector for every line, and despite this the engineer informed me that they had not spent £25 for material for that office during twelve months. It contains switches for 3,000 lines. Information of this kind has a bearing on the life of the plant and the extent to which depreciation from wear-and-tear may be expected.

At Chicago a letter written by the engineer of the Los Angeles Company to the Automatic Electric Company was shown to me. It was dated 26th July, 1909. The following is an extract:—

"There are at present 11,000 manual telephones; 4,850 are main line, the balance, 6,150, private branch exchanges, with stations and extension telephones. Approximately, 22,000 automatics; 19,000 are main lines, 3,000 are party and extensions. The actual expense of maintenance and operation for the 11,000 manual telephones for the month of June was 10 dollars 10 cents more than the actual expense for maintenance and operation of the 22,000 automatic telephones for the same month, and we find there is little variation from month to month. This shows a saving of about 50 per cent. in automatic equipment. Another very large item in favour of the automatic system lies in the fact that the automatic telephones are scattered over a very large area and are working out of ten different exchanges, while the manual telephones all work out of one exchange and are all located in a small area. It is safe to say that if all the automatic telephones were working out of one exchange and in as small an area as the manual telephones they could be maintained and operated at a considerably less cost. We are so well pleased with the service and the economy derived from the automatic system that we are getting ready to cut all our manual telephones except private branch exchanges over to automatic."

This cut-over has been made, and it was stated to me at Los Angeles that the result fully justified the change.

For the year ended the 31st December, 1910, the Automatic Company's revenue at Los Angeles (within the city) for about 41,000 telephones of all kinds of service was £219,508 13s., or about £5 7s. per telephone. The expenses were as follows:—

	£	s.	d.
Operation and general	53,058	0	0
Maintenance	39,010	11	0
Taxes	17,210	12	0
	109,279	3	0
Charged to plant addition	58,657	9	0
Balance	51,572	1	0
	£219,508	13	0

Depreciation is not included. If we omit the taxes the cost per telephone is about £2 5s.

The Bell Company, operating manually, had about the same number of telephones. Their revenue within the city was £232,366 1s., or about £5 13s. 4d. per telephone. The expenses were as follows:—

	£	s.	d.
Operation	106,623	7	0
Maintenance	47,595	14	0
Taxes	15,471	6	0
	169,690	7	0
Balance	62,675	14	0
	£232,366	1	0

Depreciation is not included. If the taxes are omitted the cost per telephone is about £3 13s. 6d The operating-cost only of the manual is double that for automatics. Care has to be exercised in using these figures, and it would not be justifiable to deduce any more from them than that they support the general claim that automatic telephones can be operated at a considerably cheaper rate than manual.

The rates of the Home Telephone Company (the automatic) are:—

	Per Month. £	s.	d.
Business—			
Wall telephone	1	0	10
Portable telephone	1	2	11
Residence—			
Wall telephone	0	8	4
Portable telephone	0	9	4
Two-party business—			
Wall	0	16	8
Portable	0	18	1
Four-party business—			
Wall	0	14	7
Portable	0	16	8
Business extensions	0	4	2
Hotel extensions	1s. to 0	2	1
Switchboards—Up to 20 lines	(each) 0	2	1
20 to 30 lines	(each) 0	1	11
30 to 50 lines	(each) 0	1	8
50 and over	(each) 0	1	0

If the hotel is wired by the company actual cost is charged. If they supply a booth, the charge is 50 per cent. extra. Trunks are charged £1 5s. per month for the first; all additional trunks-£1 0s. 10d. per month. Each switchboard station is charged 4s. 2d. a month; each station con

nected to the board but outside the building, 4s. 2d. a month. The company does not care for business party-work, and has scarcely any, but the rate is as above.

At Omaha (population 185,000) there are four automatic exchanges: A Omaha, 3,500 lines; B Omaha, 3,000 lines: Keith line switches, three-wire system. South Omaha, 1,100 lines; Florence, 110 lines: Keith line switches, two-wire system. There are no party lines, all being individual lines. The A exchange has equipment for 4,000 lines and floor-space for 10,000. The room is 90 ft. by 50 ft. The space occupied is about 80 ft. by 22 ft. The ringing here is *not* automatic. The subscriber has to press a button to ring. The staff here consists of—

	Dollars.
1 wire-chief	90
2 information clerks	60
1 record clerk	30
1 complaint clerk	30
4 day switchboard-men at 90, 65, 60, 50 dollars	265
1 night switchboard-man	40
1 apprentice	35
Total operating per month	550 = £1,375 per annum.

There are also 4 trouble-men for outside at £15 12s. 6d. a month each, and 2 men repairing telephones at £14 11s. 8d. each per month. It will be interesting to compare annual costs again, from these actual figures, with a most approved type of common-battery manual board.

Manual C.B. board, first cost for 3,500 lines at £3 (this is placing it lower than before, as it is smaller) = £10,500, plus £2,300 for erection, or about 13s. 4d. a line = £12,800. Automatic will cost, say, £5 a line = £17,500, plus £2,300 to erect = £19,800. Difference, £7,000.

Automatic annual charges:—		£
£7,000 interest and depreciation at 4 per cent. and 8 per cent. = 12 per cent.		840
Operating-costs as shown		1,375
Dials, 3,500 at £1 each = £3,500; at interest 4 per cent., depreciation 12 per cent. = 16 per cent.	£560	
Dial maintenance at 1s.	175	
		735
Total		2,950

Manual costs:—	£
1 wire-chief	225
2 switchboard, trouble, and frame men, and cord-repairing, &c., £180 and £160	340
44 operators at £70	3,080
3 monitors at £110..	330
2 supervisors at £160	320
1 observation clerk	100
	£4,395

Difference in favour of automatic = £1,445 per annum.

The trouble-men and telephone-repairers would be required for either type of exchange.

But this is not all. The automatic system will work into other exchanges at practically the same cost. The manual would require B boards, space for them, and operators, and this method of working would reflect itself in the A boards, and more positions and more operators would be required there owing to each operator being slowed down owing to the existence of B boards.

Council Bluffs is a city of 35,000 people across the Missouri, five miles from Omaha. The telephone system is *manual* and is owned by a different "Independent" company, which agrees to intercommunicate. A charge of 5d. is made for each communication. Heavy charges are levied by the Bridge authorities for supporting the cable across the Missouri. As showing how easily one system can work into another, it may be mentioned that an automatic subscriber at any of the Omaha exchanges rings direct into Council Bluffs, a lamp lights there, and the connection is taken up and completed. A Council Bluffs subscriber requiring an automatic subscriber in Omaha rings in the ordinary way, and the operator at Council Bluffs, who has a dial, completes the connection automatically.

The automatic office at South Omaha was visited. The building is two storied, brick, and much too large. There are 1,100 lines. The ringing in this exchange is automatic. Three men are engaged here, and one for line and instrument trouble. Their total monthly salaries are 285 dollars, or £59 7s. = £712 4s. per annum. Repairs are effected by the trouble-men at a small bench at the end of the switch-room. The B office has 3,000 lines, and has one man less than the A office already referred to. These exchanges had not been paying; the stock was heavily watered; the company was placed in the hands of a receiver, and is now recovering itself. They stated they paid their way and put away about £3,500 a year. The engineer informed me they had put in a manual board at St. Joseph's—population 55,000—in 1910, and that they now regret it was not automatic. He said he would not install anything but automatic now after the experience he has had of its working. A number of calls were made and conversations held. The speech was good in all cases. Calls took from four to seven seconds, according to the number called, to complete the dial movements. This agrees with results got at San Francisco and Los Angeles, and later at other places. Lincoln, seventy-eight miles

distant, where the exchange is also automatic, with many thousand subscribers, was spoken, there being thirteen miles of underground cable in circuit, and the result was quite satisfactory. The manager at Lincoln informed me that the system gave them every satisfaction.

At Omaha there are flat rates of 4 dollars 50 cents (or 18s. 9d.) a month business, and of 2 dollars (or 8s. 4d.) a month residence. The radius of the exchange-area is six or seven miles. There are no party lines used.

The next step was to Chicago, where there were eight automatic exchanges just opened with about 22,500 lines. A vigorous automatic campaign had been conducted for some time. There was a clause in the franchise which required that 20,000 automatic telephones should be operating by the 1st June, 1911, or the franchise would be lost. The automatic movement was progressing rapidly, as they had applications for about 45,000 lines, were getting more, and were connecting up as fast as they possibly could. More exchanges were to be opened when found necessary.

Five of these exchanges were visited. The Plymouth exchange is located in a three-story building, leased. The exchange-room on the second floor is 30 ft. by 80 ft.; and in this space are accommodated the main frame, the switches for 4,700 lines, the wire-chief's and the trouble desk. The room will accommodate apparatus for about 5,200 lines. Everything is placed rather closely. At the trouble-desk is a Gray's telautograph on which announcements of trouble received at the Chronicle or central office are promptly sent out to the office concerned, and recorded. This saves time and delay. The batteries, charging-plant, and power-board are on a portion of the lower floor. The ringing is automatic and is of four frequencies—16, 33, 50, and 66—the voltage-range being from 50 to 150. Machines give the ringing in the daytime. For night ringing the battery is used passed through transformers and special vibrating-apparatus. Forty-six volts are used for speaking. The receivers are without permanent magnets: there is only the coil used. This has been well tried and has been found to give very satisfactory results.

These Chicago exchanges are all on the two-wire system and have the Automatic Electric Company's most recent developments applied to them. The Plymouth exchange has the following *personnel*—Manager, about £27 a month; 4 superior switchmen at £20 16s. a month each; 1 wire chief at £20 16s. a month: total for inside staff, £135 per month. For outside work and attending to telephones there are 3 men at £20 16s. a month each. The rates of pay are high, but not quite so high as in San Francisco and the West.

There is no repair-room in any of these exchanges. They are, of course, new yet. There is a bench in the switch-rooms with a few tools. The repairs are effected at that by the switchmen. One trouble-man was said to be enough for about 1,500 telephones when they are not too scattered. Telephones give no more trouble on this system than on manual, as they are ordinary C.B. type with dial attached. The dial is an extra piece of apparatus to get out of order, but from inquiry made as to the trouble that results, and judging from the number of trouble-men usually employed, the cost of maintenance of the dial is low.

Brooks office has 4,500 lines and space for 6,000.

Chronicle office has about 5,000 lines and space for about 7,000. This is practically the main office, as it is here the "information" and "complaint" for the whole system concentrates and is then passed on to the various exchanges. This makes for economy of staff for this class of work, and expedites handling. There is a four-position board for these purposes, which will be increased as required.

Cottage Grove has about 4,000 lines and is located in a brick building specially built. Everything was on one floor so as to keep good supervision and reduce the labour.

The number of persons in the different exchanges and the rates of pay correspond with what has been set forth for the Plymouth exchange. The apparatus is practically the same in all, only the lay-out differing somewhat to meet the varying shapes of the rooms or to avoid pillars.

The following flat rates are being charged per annum: Business, 84 dollars, or £17 10s.; residence, 50 dollars, or £10 8s. 4d.; four-party business, 39 dollars, or £8 2s. 6d.; four-party residence, 30 dollars, or £6 5s.

The Bell Company's charges are 125 dollars per annum for business flat rate, but they have quite involved charges for various kinds of service. The Bell Company has recently announced its intention to relieve telephone rates to the public to the extent of 400,000 dollars per annum, or £83,333.

The Illinois Tunnel Company, operating the automatic telephones in Chicago, has made arrangements with the Postal Telegraph Company for the use of its wires for long-distance communications.

About £500,000 a year is being spent in development of automatics in Chicago. Dividends are not being looked for at present.

Much could be referred to to show how automatics are developing. Newark (population 27,000) is a new automatic, replacing a thoroughly good common-battery board. As the company has already got the common-battery telephones, 3,000 lines are being equipped and only dials supplied. Honolulu, about eighteen months ago, put out a good common-battery board and put in automatics. At Dallas, Texas—population 100,000—automatic for 9,000 lines is being installed and is nearing completion. The contracts were got in thirty days, when soliciting ceased. There are to be four exchanges. The Bell Company had already 17,000 telephones in the city. The rates of both companies are: Business—60 dollars (or £12 10s.) per annum, unlimited service; residence—25 dollars (or £5 4s. 2d.) per annum, unlimited service. At Houston, Texas, an automatic exchange is almost completed for 4,250 lines. There are two exchanges, and the population is about 90,000. At Quebec (population 80,000), automatic equipment for 3,000 lines is in progress.

In Canada the Provincial Governments of Alberta, Saskatchewan, and Manitoba have acquired the telephone systems. Alberta has equipped Edmonton, which has now 3,800 lines; Lethbridge, with 1,000 lines; and is now equipping Calgary (population 50,000) with 4,800 lines. Saskatchewan

has equipped Saskatoon, and the equipment of Regina is contemplated. Winnipeg (population 150,000) was negotiating for 15,000 automatics, but there is no information whether this has been undertaken.

Havana, in Cuba—population 400,000—in 1910 had only 3,500 telephones. They ordered automatic equipment for 6,400 switches, then another 3,400, and again 3,000, or a total of 12,800. This was the advance in a little over a year.

Automatic opposition to the existing Bell Companies was being considered at—Seattle, population 300,000; Salt Lake City, 100,000; Wichita, Kansas, 65,000; Baltimore, Maryland, 600,000; Marshalltown, Iowa, 15,000; Leavenworth, 40,000; and at Winona and other small places. Automatic exchanges at Grand Rapids, Columbus, Dayton (Ohio), Richmond, Champaign, Urbana, and Decatur were also visited.

Grand Rapids is one of the oldest automatic exchanges. It is a three-wire system, and there is a good deal of No. 14 iron wire strung aerially. Different types of automatic apparatus are to be found here representing the various stages of development. There are over 11,000 telephones on about 9,000 lines. The population is about 130,000. There are two branch exchanges of about 1,000 lines each, and one unattended exchange. Most of the apparatus is of the older type—that is, a first selector for each line. Local batteries are at the subscribers' telephones. The company estimates that each telephone costs them 2 dollars (or 8s. 4d.) a year in excess of what it should, owing to the local dry battery. This includes labour. They have open aerial wire, in some cases two miles long. They do not transpose, and find no trouble from cross-talk. The longest lines for local service are about four miles. About 11 men are employed for outside work. This is due to the amount of open wire and the local batteries. In wet weather they increase to 15, as faults disclose themselves then. They are about to change to common-battery working, and hope thereby to effect considerable savings. They will also gradually displace first selectors by Keith switches, and thereby reduce the apparatus to be kept in order. There has been no subdivision of exchanges in three years, but some more small exchanges are to be installed. They have 36 toll lines. These take in about 80 of their own exchanges. The longest toll lines are about 150 miles, and one to Columbus is about 300 miles. They have about 1,800 toll communications a day. In looking into wear-and-tear some switches were seen that have operated from 450,000 to 600,000 times. Some shafts, wipers, and springs have been replaced, but they never need to replace many. The signs of wear were very slight. All this old apparatus is working now as well as ever, and giving good satisfaction to the subscribers and the company. In seven years the cost of renewals on apparatus for 5,000 lines amounted to 962 dollars, or £200 8s. 2d. The engineer said he considered the apparatus would wear for forty years; but of course it will be modified before that, and may even become obsolete. I spoke over several lines and found speech quite good. There are 21 persons in all the offices, including the engineer, the janitor, and the boy. There are 15 men, including the engineer, janitor, and boy in the main office. They are employed thus: 3 men take care of trouble-tickets and test with the subscribers; 3 are mostly repairing; 1 is going about testing switches in position; 2 are on at night; 2 overlap so as to keep up the force during hours when some go off duty; 1 attends to power plant; 1 attends to anything he may be called upon to do; 1 is janitor. Of these only five get the regular rate of pay. The highest rate is 85 dollars, or £17 14s. 2d. The average may be placed at about 65 dollars (say, £13 11s.) a month, or £2,799 for the main exchange and £453 for the other three per annum. The engineer is paid 125 dollars a month, or approximately £316 a year. He has grown with the business. He belongs to Grand Rapids and has never had experience in any other exchange. He was with the company when the manual was in operation, and would not like to return to manual working. Only one of the men looking after the switches in Grand Rapids has had former experience. They have got their experience on the plant. Nothing special in mechanical training is called for. Men who can manage common-battery manual can do automatic. There is no person in the branch exchanges after 10 p.m. A man attends to each, except the unattended one, from 7 a.m. to 4 p.m., and another man takes up duty from 4 to 10 p.m., at 30 dollars a month. There are 4 trouble clerks, 1 recording trouble clerk, 2 record clerks, and 3 information clerks, at about 30 dollars a month each = 300 dollars or £62 10s. a month = £750 per annum.

At the main office "information" is attended to for all the branches and the sub-exchange. Trouble can be attended to at the main or at the branches. All trouble on the unattended exchange is supervised from the main office.

It was particularly noticed that in the apparatus-room there were only 3 persons moving about attending to the switches—that is, watching for lamps, attending to bells, and operating switches to see they were quite free in all respects. Others were at various works, such as repairing switches, &c. There were 12 men in the room. This was due to the change being made to common-battery working. Later, when the change is finished, this number will be considerably reduced. It could be further reduced if the two-wire system were employed. There is a toll board for 12 positions, 3 record positions, also a switching-board of 3 positions to connect subscribers to tolls and to take care of the private branch exchange and pay stations that are manually operated; 1 pay-station position and 1 rural position. For all these purposes and for information, complaint, and other record-work there are about 50 girls for night and day work.

The unattended sub-exchange is about two and a half miles from the main exchange. It is a rented room about 24 ft. by 10 ft. There is a much smaller room beside it for a 60-ampere hour accumulator battery, which is charged from the main office. Three 100 line boards are in position and nearly all operating. There is room for another 200 lines. We called up a distant exchange, Holland, and spoke well. We timed how long it took to ring from one telephone to another in the same room by getting the connection through to the main office and back, and found it to be about as at other places—seven to eight seconds. It was shown how the secondary cells operating a relay can send a signal to the

main office when they are of too high or too low voltage, and thus enable the main exchange to cut in or out counter E.M.F. cells as may be required. This is done by simply stepping a connector and rotating it to different contact plates in the banks to which the necessary lines are attached. Supervision of every subscriber's line can be obtained in the same way. Testing can be done. In fact, complete supervision is exercised from the main office. This, too, is done not through direct trunks to the sub-office, but through a branch office where wires are picked up to the sub-exchange. This keeps the wiring at a minimum. While in the exchange we saw and heard the switches completing calls put in by subscribers. This exchange is visited by a switchman once or twice a week. There is no special expense, as the car passes the door.

Referring to the main exchange, it was stated that a short time prior to my visit the general manager had not been inside the switch-room for four months, and had not during a month received a single complaint.

Some inquiries were made by me of persons who had both manual and automatic telephones, and in nearly all cases the automatic was preferred—speed and secrecy were the features approved of. The rates are: Business—36 dollars, or £7 10s., for one mile, and 8s. 4d. per quarter of a mile; residence—24 dollars, or £5, all over the area; party lines—residence, 20 dollars, or £4 3s. 4d., all over. There are only 200 party lines in the whole of the exchanges. Business party lines are not given. This company does not solicit business. This exchange pays 8 per cent. The Bell Company has two exchanges here with about 9,000 telephones. They have a large number of party lines.

Holland, forty miles distant, is a small place of about 5,000 inhabitants, and has 800 automatic telephones. The exchange is in charge of a man who gets 65 dollars, or about £13 11s., a month. He also attends to trouble, and is much out-of-doors, so a young woman is employed who takes care of the switch-room. She sits at the wire-chief's desk and looks after complaints, gives information, &c. If there is anything she cannot do she makes a note for the chief to attend to it on his return. She always knows where the chief is so that he may be called if anything requiring his return to the office should arise, which has been found to seldom occur. There are two other men—one at 55 dollars, £11 9s. 2d.; one at 30 dollars, £6 5s. The girl gets 25 dollars, £5 4s. 2d. This is working an exchange of 800 subscribers for 2,100 dollars, or £437 10s., a year.

It was stated in connection with Grand Rapids automatic exchanges that the staff there except one man got all its experience in those exchanges. Mr. Fisher, now of the Automatic Electric Company, Chicago, had only been in Grand Rapids Exchange one week when he was given charge of switches for 1,000 lines, and he had never been in an automatic exchange before that.

At Manchester, Iowa, there is a small automatic installation of 375 lines, for which they charge 24 dollars (£5) business and 15 dollars (£3 2s. 6d.) residence. They run quite satisfactorily, and never had a man there who had been in any other automatic exchange or works. They have operated their own plant from the beginning.

From the preceding particulars of Grand Rapids it will be seen that it is not an ideal or up-to-date automatic exchange, as it is equipped in a manner that would not be adopted in such exchanges to-day, is worked with local batteries instead of common battery, and has an excess of open aerial wire. Notwithstanding these features, which, however, are being gradually corrected, it is giving service that is satisfactory, economical, and producing dividends at a rate that must be admitted to be moderate.

The thought that naturally flows from this, and that is supported by the class of service being given by similar apparatus at other places, such as Columbus, Dayton, and Los Angeles, is that if automatic apparatus of eight or nine years ago bears the comparison that has been indicated with the improved automatic development of to-day, and that which has largely taken place during these last two or three years, how equally likely it is that ten years hence the apparatus of to-day will be rendering service comparing not unfavourably with the best then obtainable.

The toll rates at Grand Rapids are 5d. for twelve miles and 5d. for each additional twelve miles up to sixty miles, thereafter 2½d. for about each six miles. Toll lines are phantomed and composited and leased for telegraph purposes at about £4 a mile.

Columbus (population 180,000) has 13,600 telephones on about 11,000 lines. The telephones are mostly automatic. The toll lines here are phantomed, composited, and leased for telegraph purposes at rates ranging from £1 to £4 a mile. There are telegraph repeaters and accumulators to supply current for telegraph purposes. Some of the toll lines can be worked manually or automatically. The toll board is made up of 2 farmers' sections, 2 pay-station sections, 4 recording sections, 23 toll sections, and 1 chief operator's board detached. There is also a switching section. There are several special classes of service here which cannot be referred to, as they would take long to explain. For the 10 automatic exchanges in the city there are 32 men for switching-work, 14 for attending to trouble outside and at the subscriber's telephone, and 2 others, one of whom has a buggy and the other a bicycle.

A particularly noticeable feature was the number of quite young men, really lads, who were about the switch-room. On commenting on this to the superintendent he said they liked to train their own men, and that now they had an unusual number of apprentices as they expected to lose some of their best men to Chicago, where automatics were rapidly coming to the front, and they wanted to be prepared. They have what serves as a school of instruction for their young men. No special mechanical skill is required, and they find young men soon become useful. They do not consider a man a switch-attendant until he is so qualified that they pay him 55 dollars, or £11 9s. 2d., a month. It would be more economical to have a certain number of good switchmen, but men have to be trained so that contingencies may be met.

There are 6 information positions, 2 complaint positions, and 3 record clerks tabulating fault tickets. Special care is taken with faults. A special book is kept so that it may be seen at a glance over a period of a year or two what trouble each subscriber has had. This is of great assistance. This record was examined. It was seen that in five months 100 subscribers had 124 troubles; another 100, 91

troubles; yet another 100, 98 troubles; and 300 telephones had 175 troubles. At an unattended exchange of 276 subscribers the actual faults per 100 subscribers in five months were 94, 119, and 107.

In the main exchange there is only *one* man in attendance from 11·30 p.m. until 7 a.m., and two information operators at night. There are only two other of the exchanges that have permanent attendants in the daytime. There is one attendant at each by day and none at night. The main exchange is the only one that has a switchman on duty at night.

East branch office has 700 lines equipped and a capacity for 1,200. It is in the dining-room of a residence, and is cared for by a man who lives in the building with his family and who looks after another exchange of 260 lines. Repairs are effected at a small bench in the switch-room.

Franklin Park is another attended exchange. It is three miles from the main office. The building is of brick, with a concrete interior. There are 680 lines in use and space for a few hundred more. The engineer stated that before this building was erected it was figured it would cost 48,000 dollars (£10,000) to supply the district from the main office, while the actual cost by a branch exchange was 28,000 dollars, or £5,933. The other offices range in size from about 300 to 60 lines. Several of them are in special-type buildings which cost from 1,500 to 2,000 dollars, or about £312 to £416. It has been found such elaborate buildings are not necessary. Control of these exchanges is got automatically from the main exchange. It is proposed to have four more sub-exchanges of 800, 300, 200, and 100 lines. A sub-exchange of 100 lines is found to be cheaper than four-party service.

Before introducing automatic, Columbus had, from 1900 to 1905, a manual common-battery board which was working well. Extensions were required, and it was figured that it would pay to install automatics, which was done. They have been unable to sell the manual plant. Automatic has been in operation at Columbus for six years. The officers express themselves as well pleased with the plant and its operation. Some years ago Columbus (in Georgia) had an automatic equipment. The exchange came under the control of the Bell interests, and the automatic was put out. The apparatus was then purchased for extensions by the Columbus (Ohio) Company and is in operation to-day. There were 1,000 lines. Wear is here, as in other automatic exchanges, not a matter of any consequence.

For a considerable period Columbus and Dayton, seventy miles distant, and both automatic, operated their toll lines between those places automatically. A subscriber at Dayton would call the toll operator there, who would make the charges and then call direct to the subscriber at Columbus, and *vice versa*. This very largely increased the number of calls that could be made over the toll lines, as many as 175 calls a day being made on one circuit, mostly in the day hours. The direct working has, however, been abandoned, as the authorities having control of the toll lines did not keep them in sufficiently good order for this class of work. Similar methods prevail between automatic exchanges in the Montana region, and Columbus is working tolls in that way with Newark and Lancaster, twenty-five to forty miles distant, to the great advantage of the work.

A number of people were called on by me, and inquiry made whether manual or automatic service was preferred. The replies were about 80 per cent. in favour of automatic.

The rates are—

	Per Annum. £ s. d.
Within city limits—	
Business	8 6 8
Residence	5 0 0
Outside city limits (extra each half-mile beyond city limits)—	
Business	1 5 0
Residence	0 16 8
Two-party lines (within city limits)—	
Business	7 1 8
Residence	3 15 0

Dayton (population 120,000) has about 7,600 automatic telephones. The apparatus here is old-type, local batteries at subscribers' telephones and the like. They are changing gradually to the two-wire system and introducing common battery. About 1,000 telephones have been altered. The switch-room staff consists of 8 men. There are 7 clerks for information and trouble, 1 man who attends to private branch exchanges, and 3 men in the workshop. Wages are the same as at Columbus. Cost of material for maintenance is low. They contemplate nine sub-exchanges, and would like them, but no money is available, as the Ohio Independent Companies have been bought by J. P. Morgan, and there is no money forthcoming for any purposes. It was noticed that there was a girl at a position whose only duty was to give baseball results to the public as they called up. She was quite busy, too. This class of service sometimes requires two operators, and is done free. Some other companies also give that information to the public. The rates are, for individual lines—Business, £8 6s. 8d. per annum; residence, £5 per annum: throughout the area.

Richmond (population 22,000) has an automatic system. The main exchange has 2,077 telephones. There are three unattended sub-exchanges, each about a mile distant from the main exchange, having about 290, 220, and 100 telephones. There are 170 telephones on party lines, and about 300 on farmers' lines—total telephones about 3,200. The staff consists of 4 men and 2 apprentices, drawing 375 dollars, or £77 1s. 4d., a month: 2 girls, 35 and 30 dollars, or £13 10s. 10d., a month: these are inside. Outside are two trouble-men drawing £22 18s. 2d. a month. In this exchange the working-expenses per telephone are £1 12s. This includes every expense up to interest on bonds and dividends. They pay 5 per cent. to 6 per cent. The rates are, for individual lines: Business, £7 10s. per annum; residence, £3 15s. per annum: anywhere in the area. Toll lines are worked automatically between this exchange and the automatic exchange at Dayton, forty-two miles distant. This increases the carrying-capacity of the toll lines. They have also worked with Columbus, 112 miles away, in the same manner.

Champaign and Urbana (population about 20,000) have 2,800 telephones, mostly automatic. Urbana is about two miles from Champaign and is the site of the State university. The university

has 200 telephones. The staff at Champaign, not including the manager, is 1 wire chief, 100 dollars; 2 switchmen at 50 dollars, 100 dollars; 1 information and trouble clerk, 22 dollars; 1 night switchman, 35 dollars: total, 257 dollars per month = £53 10s. There is a university student who is learning and is paid 1s. an hour when he is engaged. There is also 1 outside trouble-man at 70 dollars per month, or £14 11s. 8d.

At Urbana there are 600 telephones. The apparatus for these is housed in a back room of a brick building, and there is not much room. The staff consists of 1 inside man at £162 10s. a year and 1 outside man at £150 a year. A student sleeps in the exchange, who gets £2 10s. a month for doing so.

The rates for individual lines are—Business, £6 5s. per annum; residence, £3 15s. per annum throughout the area. The radius of the area is about three miles from Champaign. Urbana then reaches another two or three miles. The manager informed me they pick up young men and train them. Their present staff was built up in this way. He stated it did not cost much for maintenance. He had been at Lewiston, and said that after the board had been five years in use it was better than it was at starting. He would say the same of South Bend. Both of these were automatic exchanges, and he found that the more automatic apparatus was worked the better it became, which is in keeping with what was stated by men at other automatic exchanges that had been visited. The Champaign exchange is paying 12 per cent., and the annual expenses amount to 7 to 8 dollars, or about £1 10s. to £1 13s., per telephone. This does not include taxes, insurance, heat, light, and the like. The whole mechanical work is done at a small bench. There are no lathes or machinery of any kind beyond vices and some small tools. The case is the same at Urbana.

Decatur was visited (population, 35,000, scattered). It has 2,700 telephones, mostly automatic, on 2,000 lines. This town is about fifty miles from Champaign. The conditions, staff, &c., are very similar to those at Champaign. The rates are the same. The manager is well satisfied with the operation of the plant and its economy. He says there are no sub-exchanges, which he considered was a mistake. He would not consider a manual board except in places where a girl had to be employed for other reasons, and would have spare time to operate such a board.

When visiting the Independent Company at Detroit it was found that at Crest, about three miles distant from the manual exchange, it had installed automatic switches for 300 lines. The subscribers on these could, by simply taking the receiver off its hook, cause a lamp to light before an operator at the main exchange, where the connection was completed by the usual cord methods. This system had been in operation only a month, but it was giving satisfaction.

At Buffalo the same thing was being done. The supervisor said that at first she was opposed to the method, but was now quite a convert to it, the results had been so satisfactory.

At Cleveland the North auto-manual apparatus had been installed about four or five miles out for a couple of hundred lines. This was arranged to be worked from the main exchange by girls at a special board. It was not continued long, as undue delay seemed to result in completing connections. This seemed to be due more to the methods used than to the mechanism.

The Strowger System.

The Strowger system is a full automatic system, manufactured by the Automatic Electric Company, of Chicago. The extent to which it is in operation, and the rapid strides it has made of recent years, have already been referred to.

At the subscriber's station a common battery telephone of the usual manual type may be used. Attached to this is a disc cut into the circuit, so as to make and break contact a number of times according to the figure pulled. Mechanism placed usually at various centres responds to the impulses given rise to by the make and break. These impulses may vary in speed up to about twenty per second. The most recent form of disc is but little complicated. There are circular holes cut in the front disc through which figures from 0, 9, &c., to 1 appear. To send in, say, number 5643 the telephone-receiver is removed from its hook, the finger is inserted in the front disc opposite the figure 5, and the disc is rotated to its stop and released. The rotation winds a spring and the five impluses are sent during the return of the disc to normal. Similarly for the remainder of the figures. The removal of the receiver from the hook actuates an electro-magnet at the exchange, which causes a plunger of a Keith line-switch to be detached from a rocking-bar and thrust forward so as to close contacts. At the same time the circuit of a master switch controlling the rocking-bar of the Keith line-switch apparatus is closed, and a step-by-step device operates to bring all the remaining plungers into a position to be ready to take up the next idle trunk when another call comes in. The step-by-step device will continue acting, and will take all the idle plungers with it until it finds an idle trunk. When the end of the bank of 10 is reached the switch will still act and select idle junction positions in a backward direction. The subscriber will receive a "Busy" signal if all the trunks are engaged. When the conversation is finished the plunger is again taken in charge by the rocking-bar, which usually controls the plungers of one group of twenty-five line-switches. Four such groups are so arranged as to enable one master switch to control the four rocking-bars, and thus enable 100 subscribers to have access to ten trunks. Keith line-switches and connectors are mounted together on the one frame. They are then conveniently placed for the multiple wiring of the subscribers' lines.

The plunger having been thrust forward and the contacts made, the first set of five impluses from, say, No. 58763 actuate the electro-magnet of a first selector, and step it up to the fifth level. Each selector and connector have ten levels and ten different contacts along each level. This is called a "bank." There are usually three such banks on each switch, but on the more recent only two. Two banks are for the contacts corresponding to ring and tip of a plug, and the third corresponding to the sleeve by which the engaged test is got. Each switch has also a shaft on which are mounted brushes or wipers, which, as they pass along any level, make contact with the terminals in the banks.

At the fifth level the shaft is automatically rotated horizontally, and the wipers pass along the bank terminals until one is found that is idle, when the shaft stops. From this position a trunk goes to a second selector in a 10,000 group, and the movement of the first selector has taken place simultaneously with the formation of the impulses by the dial in its backward movement to its normal position. The next movement of the dial 8 will step up the second selector to the eighth level, where it will rotate along that level to find an idle trunk leading to a third selector in the "thousands" groups. The next dial-movement 7 will step up the third selector to the seventh level, where it will rotate as the other switches did to find an idle trunk leading to the connector in the "hundreds" groups. The next dial-movement 6 will step up the connector to the sixth level, but the connector differs from the selectors in that it will not rotate along the level automatically. To make it rotate it is necessary to move the dial, and as the next figure of the number, which is 3, is pulled, the connector moves to the third horizontal terminal on the sixth level, and connection is now made from the calling to the wanted subscriber. As soon as this connection is completed, ringing begins automatically, and continues until the subscriber being rung takes his receiver off the hook, when the ringing is by that act cut off. In older types still in operation in some places it was necessary for the calling party to press a button to ring. When automatic ringing is being done the calling party hears that the bell is being rung. If the called subscriber is "engaged" when a connection is being sought, a "Busy" signal will be heard by the calling party. The selectors may be in different exchanges. When the conversation is completed the calling party can disassemble the connection immediately and put in another connection at once. If a mistake has been made in calling, and it is detected before the call is completed, it is necessary only to depress the switch-hook an instant and call again. It can be arranged if necessary, although it is not generally found necessary, to give what is called "back release"—that is to connect up so that the party called can free himself from the calling party.

It would lead to complication to explain how "banks" are multipled, and how by suitable arrangement of Keith line-switches used as primary and secondary switches the percentage of first selectors to the total subscribers' lines can be reduced. Provision is, however, made for these features, and for party lines, metering, coin service, and private branch exchange service entirely automatic if desired.

For numbers that have been given up, those of persons out of town, or for any numbers that for any reason are temporarily out of use, connections are arranged so that any calls to them will arrive at an "information" table, where an operator will confer with the calling party.

Alarm signals are provided, so that switchmen can promptly and with little difficulty ascertain what part of the mechanism calls for attention.

It is sometimes objected against full automatic that the dial cannot be worked in the dark. It can be worked in the dark, but not easily. That objection has been closely inquired into, and is found not to be of much consequence. The operating companies find that it is extremely rare to get any complaint on that score, or that it affects in any way their getting subscribers. "Long distance" is 0, easily found on the dial in the dark. Calls going in on that number either meet an attendant, or the office-arrangements are such that a bell is rung so that some person can be reached who can give information. "Information," or "Police," can be given numbers easily found in the dark, such as 1111. It is only on special and unusual occasions such a difficulty could possibly arise.

It is also objected that malicious calls may be made and that they cannot be traced. This is to some extent correct. But, again, the operating companies do not find this troublesome, and it is not any more serious than in manual systems. In large manual systems where connections are effected by "order-wire" from A operators to B operators it has been found practically impossible to trace connections. The best answer to these objections is that where the automatic system is in operation they are found to be purely theoretical.

Another question that arises is, Do the people where automatic is in use like it, and have they any dislike to having to operate the dial? In Los Angeles, Grand Rapids, and Columbus inquiry was made by me of persons who had both the automatic and manual telephones, and in nearly every case the automatic service was much preferred. The result of the introduction of full automatic at Munich has been referred to earlier. The users are quite satisfied.

At Chicago the Automatic Electric Company showed me probably two or three hundred letters that had been received in response to inquiry by that company of the kind of service that was being got from automatics. These letters were not sent to picked persons, but a certain number of names under each letter of the alphabet in the directory were taken, and a circular sent to all. A copy of the circular letter and of the analysis of the replies is in my possession. A large number of the replies were read by me, and fully 70 per cent. were favourable to automatics.

A point that occurs also is, Can we get men to take care efficiently of such equipment? The conclusion that must be drawn from the class of man employed at this work in the States and from the way in which they are recruited is that our young men are just as intelligent and apt as those by whom this work is being effectively performed. Any man who could comprehend and attend to manual common-battery switchboard requirements could engage equally well in automatic-switch work. At first, as the time would be short, our policy would require to be to specially and quickly train a few good men, and bring along others also, but less speedily. These well-trained men would keep installations going with the assistance of others, and time would be available then for the more leisurely training of some already partially trained and of others coming on.

The Auto-manual System of the North Electric Company.

This is a semi-automatic system manufactured by the North Electric Company, Cleveland. The system was devised by Mr. E. E. Clement, of Washington. The first installation was made at Ashtabula Harbour, about sixty miles from Cleveland, by the Ashtabula Telephone Company, for 500 lines, 460 of which were in operation at the time of my visit.

On this system subscribers have no dial. Only the usual common-battery telephone is used. Line and cut-off relays are provided at the exchange for each subscriber's line. Primary switches made up of banks of tags of ten levels and ten terminals on each level, arranged semi-circularly, are provided. These serve to connect a calling-line to the idle operator's position. There are wipers on a shaft, as in the Strowger system. When a call comes in from a subscriber the primary switch moves first horizontally and then vertically. Electro-magnets suitably disposed effect these step-by-step movements. The wipers of each switch are directly connected to the tags of a first selector. A connection is also established with a secondary switch, by the stepping of which an idle key set with a calling-lamp on an operator's keyboard position is joined to the subscriber's line. The wipers of this secondary switch for distributing to the idle operator move only horizontally. Each operator has a keyboard on which are three rows of numbered plungers, and there are three such sets. Each set has three lamps. Two light when a call comes in, and are extinguished immediately the operator touches a reply button to answer. The third lamp is extinguished when the called subscriber's line is found and connection established. The operator then sets up on the plunger-board the numbers given to her by the subscriber and presses a starting-key. This disconnects her telephone headgear from the circuit, and joins the plungers to contact drums that are continuously revolving. Impulses are sent out from these drums at the rate of about sixteen a second. The plungers that have been depressed determine the number of impulses that shall be sent out for the hundreds, tens, and units. The impulses from the hundreds take the first selector shaft to a tag on a vertical row, to which are connected trunks extending to one of ten connector switches, on which are multiplied the line of the subscriber called. The tens impulses now follow and cause the connector wipers to move horizontally to find the proper vertical row in which is the subscriber's line, and the units impulses now come into operation and effect the number of vertical movements necessary to place the wiper on the terminals of the required subscriber. Ringing is automatic, and the key set is automatically disconnected ready for another call. A "Busy" signal is given to the calling subscriber if the line called for is engaged or if all the trunks are in use.

If this system were used on a 10,000 or 100,000 line exchange second selectors and third selectors would be necessary as well as enlarged keyboards and more rows of plungers to enable the numbers to be set up. It was found that connections from Ashtabula proper could be established in from seven to nine seconds. With more mechanism this time would be somewhat increased : that, however, would not be of consequence. The claim made for this system—that a girl can answer 1,200 calls and over per hour—can hardly be accepted. Many calls were put in by me at Ashtabula Harbour, and the operator's reply came as quickly as the receiver reached the ear. After giving the number from two to three seconds are required to press the various buttons and plungers. This would be somewhat longer with more rows of plunger-keys. This method is being employed at Amsterdam, and was seen by me in operation there. Five hundred calls an hour were all that were claimed, and there was delay observed on some calls at a lower rate than that.

The time of operation of the mechanism does not in any way limit the capacity of the operator, and she is given three distinct key-sets so that at least one may be always free to set up calls on.

When several operators are required the calls are distributed evenly, as they seek the *idle* operator. As the number of calls coming in reduces the staff can be reduced, and the calls kept to those positions at which there are attendants. This is equivalent to concentration. By hanging up his receiver either subscriber can disconnect and send in a new call.

It can be arranged that where there are several exchanges on this system in an area the operators may be all located at one exchange so as to effect all connections from the one place, or the operators may be at different exchanges, as may be found most suitable. This implies control-wires, but these wires never form any part of the circuit between subscribers. They are, as it were, "teed" on to the other circuits, and can be joined to or disconnected from them as required.

The apparatus is of superior manufacture. Until last year there was only the Ashtabula Harbour installation of this system. Warren was being equipped for about 1,500 lines, Ashtabula proper for about the same number, and Galesburg for 1,800 lines. Ashtabula proper has been operating some time and is giving every satisfaction. Warren was at first somewhat doubtful, but the difficulty that arose appears to have been due to causes apart from the mechanism, and has since been corrected.

Galesburg was cut over and had to be cut back again owing it is alleged to defective outside plant. Some improvement has been made in parts of the plant, and portion of the new system is operating ; the other portion awaits improved outside conditions. Arrangements have just recently been concluded between this company and the Western Electric Company by which the last-named company can use the patents of the North Automatic Electric Company.

The repairs at Ashtabula Harbour are stated to have amounted to only 65 cents, or 2s. 8½d., in two years and a half. The people at Ashtabula Harbour liked the service given by the system so well that Ashtabula people asked the company to install it in their town, which, as has been stated, was done.

Lorimer Automatic.

The Lorimer system was seen in operation at Brantford. This system is full automatic. The installation at Brantford is serving about nine hundred lines. There is also an installation at Peterborough for about five hundred lines.

This system works satisfactorily. The calling-rate at Brantford is about five a day per subscriber. The arrangement for calling at the subscriber's station is involved. Associated with the telephone is a system of levers with internal mechanism. The number required is designated by placing the levers at the required units, tens, hundreds, and thousands. A handle is then turned, which allows impulses to flow over the line from the exchange. Three number-calls can be made in about ten seconds.

The switches are very large and strong. They are power-driven, which is a good feature. The percentages of switches fitted at Brantford is seven. The calling-rate is low. If these were installed where the calling-rate is high, 10 per cent. at least would be required, and the switches would occupy considerable space. Between groups of switches four wires are necessary. This would render the system difficult of use in multi-office areas. Ringing is not automatic. The clearing of a call is not quite instantaneous. A couple of seconds elapse before the switches resume normal. The wear is negligible, and the repairs stated to be low. Only one mechanician is in attendance during the day at Brantford, and the exchange is without an attendant at night. This system has been in operation for some years, but does not seem to make headway. The company does not impress one as being able to undertake any considerable orders or to be depended on to continue supplies.

Altogether the impression formed was that this system would not fulfil our requirements.

Stromberg-Carlson Semi-automatic.

At Rochester the Stromberg-Carlson Telephone Company were found to have a semi-automatic system which had been in operation on about a hundred and thirty lines in their factory for about eighteen months and was giving satisfaction. They had equipped and erected switches for 1,100 lines in a sub-exchange about four miles from the Independent Company's main exchange. This was not, however, in operation, and although that is some months ago it does not appear that the system is yet operating as a part of the exchange service.

A description need not be given, as the system is only in the developmental stage, and is referred to only to emphasize how various companies are seeking automatic means of giving telephone service.

The Western Electric Company's Semi-automatic System.

The Western Electric Company in New York, after years of development-work, have installed a semi-automatic system in their factory at West Street as a private branch exchange, but so equipped that it represents an exchange unit of 2,000 lines forming part of the multi-exchange area of New York City. There are 450 subscribers' lines in operation, and there are trunks leading to two city exchanges—viz., to Cortland and Chelsea.

The ordinary common-battery telephones are used by the subscribers. The manual portion of the board, where the operators are, has five outgoing and two incoming positions. There are lamps to indicate the calls and jacks to plug into. There are no multiples used, and only single cords, about twenty-five each position. There are line and cut-off relays, meter keys, and supervisory lamps. B boards are not required. Each girl can attend to about three hundred and fifty calls an hour, and to more for a short period when necessary. Generally up to this stage the provision is the same as for manual C.B. with the exceptions stated.

On a subscriber's lamp lighting the operator plugs in. This automatically cuts in her headgear and a special keyboard. The line lamp goes out and she gets the number and strikes it up on the keyboard before her.

The keyboard has four rows of keys or plungers, each row numbered 0 to 9. The rows are for units, tens, hundreds, and thousands. There is a fifth row which has keys marked "W.E.," "Chelsea," "Cortland," "L.O.," "Error," and so on, as may be required. The ringing is automatic, with breaks in it. Subscribers connected together can flash in on the supervisories to recall the operator. After setting up a number on the keyboards the keys remain down only a short time. The operator, by pressing a key marked "L.O.," or "Listening out," can disconnect herself from any circuit. The plugging of any cord also automatically cuts her off a former circuit and connects her to the circuit plugged into. The operator can come in on any circuit by pressing a special key. When the conversation is finished subscribers hang up the receiver. The automatic apparatus does not disassemble until the cord is removed. There is an "error" key, so that if an operator has made a mistake on the keyboard, by pressing that key the automatic apparatus, so far as it has been set up, disassembles.

If a subscriber on being answered has forgotten the number, as the operator is busy she cannot wait for him, but she takes up another cord and answers another call. She can come to the former subscriber at any moment by pressing a key, or he can flash her back when he is ready.

Associated with the special keyboard there are two sets of "cord finders, registers, and senders." These are called "A" and "B," and "A" is always selected first in this board. It is intended in future to make these become used alternately. If "A" is in use, "B" is then automatically brought into use if one call quickly follows another. There is also a row of six green lamps connected with the cord-finders, &c.: these are low down on the manual switchboard-panel. As the automatic apparatus, set in motion and controlled by the keys struck, progresses, the lamps light and then extinguish, so that an operator has really a guide as to the progress of a call, and if a lamp remains alight she knows something has failed to act properly and she notifies the proper person of the trouble. She also knows that these subscribers are not connected, and she can cut in and explain. By leaving the cord in the jack the apparatus is held in place and the switchman can speedily locate the trouble. The keys remain depressed only until the impulses have been recorded by the registers; then they restore automatically.

As soon as a plug is inserted in a jack a cord-finder (away on the frame), which has three sets of wipers at 120 degrees apart, begins hunting for the cord used. It does this by circuits suitably arranged. This cord-finder switch moves always forward over the banks and remains in its last position until required to hunt for a cord—*i.e.*, really to respond to impulses. This arc movement is effected by a magnet becoming energized and a magnetic-clutch effect resulting so that the switch is taken round as long as the magnet is energized. Immediately the cord is found the switch stops. The stopping is

effected by suitable relays cutting off current from the energizing-magnet and closing circuit for a stopping-magnet, from which current is at once cut off when the cord-finder has stopped. The press-buttons of the operators' keys are all connected to earth, and stand free from everything until pressed. When pressed they bring earth into contact with springs, into which they insert, and this sets up a train of relay movements, which thereby transfer the numbers set up, by means of impulses, to the registers. When the registers take up the necessary positions the operator's keys are released for use again, although the registers may not have completed transferring the numbers to the first, second, third selectors and final connector. If, however, a call comes quickly for a second connection the keys are released so quickly that they are practically always ready for use by the time an operator can take up another cord and insert it in the calling-jack to get the number. The operator then strikes the keys. If she has them all struck before the train of movements formerly set up has been completed, and in connection with which the A set of registers and sender is required, then by relays the connections are so disposed that the numbers of the second connection she is making are transferred to a second set of relays which govern the second or B set of registers and sender, so that there may be no delay.

When a jack is plugged into, a green supervisory lamp on the plug-shelf lights and remains alight until the subscriber answers. This light blinks once as soon as the train of connection through the automatic apparatus up to the bell beginning to ring has been completed. It is thus, if timed, a guide as to the time occupied by the apparatus in doing its movements from the answering of the subscriber to the bell ringing, and then of the time the called subscriber takes to answer. Several calls were timed. It was found that the operator plugged in under three seconds, and that the time from the depressing of the keys to the commencement of the ringing was seven seconds in the case of the highest numbers.

When a line called for is "busy" the white supervisory lamp lights and flashes. This signal is understood by the operator, and she informs the subscriber accordingly, and takes notes so as to complete the "busy" call later. When the line is not "busy" the white supervisory lamp glows as soon as the ringing starts, and darkens when the called subscriber takes up his receiver. Lamps remain dark during conversation. On both glowing the cord is removed which disassembles the mechanism.

The answering-jacks may be multipled on the manual board to aid team working. This may speed up the service a little.

Cords are not absolutely necessary. It is as easy to arrange for a distributor to mechanically seek an idle operator as it is now arranged to find a cord made "busy" by being plugged into a subscriber's jack. The subscriber never hangs up until conversation is finished. Howlers take care of cases where receivers are left off the hook. The American Telephone and Telegraph Company, for whose purposes this system has primarily been designed, considers it is desirable under the circumstances that prevail in the large cities in which they operate that the subscriber should have access to the operator under all conditions.

Metering is the same as on ordinary manual boards. Party lines, private branch exchanges, and coin service are also provided for. The system is flexible, and practically anything can be done. The system has been specially designed so as to be capable of being connected to full automatic at any time.

All movements of switches are forward, all are rotary; there are no vertical movements—no falling of shaft or jarring. The whole apparatus is power-driven—2 horse-power is sufficient for 10,000 lines. The power-driven apparatus can be either partially or wholly shut down at night or during slack periods. Arrangements can be made for part of the mechanism to take care of calls or for any part to be started up when a call comes in. The apparatus is all well made and finished, and does not call for much mechanical attention.

On an average about 9,000 calls a day are put through the exchange. The calling-rate is high—about twenty per subscriber per day. The errors fluctuate from 1·5 per cent. to 0·5 per cent., and on some days are as low as 0·3 per cent. An error means anything that requires an operator to make out a trouble ticket. The best results got on manual exchanges are 2 per cent. of error, and this is not often attained, the more frequent results varying from 5 per cent. to 10 per cent.

The relays are placed on the top of the last frame. There are two sets—one for A and one for B registers and senders. Some of the relays are for district, office, stepping, trunk, &c., purposes. Other relays are for rotating. There are twenty of these. The first ten are for the even 100 and the next for the second 100, as the banks of tags are 200. It may be said that the grouping on this system is not in tens or hundreds, as in the Strowger, but any number of trunks may be used.

The cord-finder is arranged with three wiper sets 120 degrees apart to move round the levels, and always goes forward. It remains where stopped until required to move to find a cord. It may move one space only or several, according to the cord used. The bank is the standard size. Banks of this kind and for other purposes with the brush wipers have been subjected to a time test, and have been found to have a life of seventy-five years and still be good for service. The wipers are moved by a magnetic clutch. A wheel is continually in motion, and associated with it is a magnet winding. When a jack is plugged the sleeve connection completes a circuit which causes a cord-finder to hunt for a busy cord. The cord-finder switch is clutched and revolved. When the cord is found the magnet is demagnetized and another relay—the stopping relay—is operated, which stops the switch and immediately itself ceases to be energized. To the right-hand side of this switch is a set of springs arranged vertically; further to the right is a shaft carrying a set of separated insulation-pieces. These pieces are cammed or cut on their circumference so that a middle spring against which the cams may bear makes contacts in different ways. The cams are eighteen in number, and are differently cut so that the contacts occur in a certain order according to circuit requirements. The registers have cam-shafts, contacts, friction clutches, wipers, and banks not unlike the cord-finders. Coming to the selectors, we find the first selector has on the left-hand side a shaft with fingers mounted spirally about it. They also have spring contacts, cam-shaft, and magnetic clutch on the right-hand side similar to the others.

The left-hand-side finger-shaft has a magnet and clutch. On being energized the finger-shaft is kept revolving until the proper finger is in position to trip the wipers of the level required. These wipers, being tripped out of place, as they revolve with the switch make contact on the tags as they move around, while the wipers at the other levels, not being tripped out, pass over the tags at their levels, but do not touch them. This process goes on through the selectors until the connector is reached. The connector has on its top a special kind of impulse-maker, so that it can find any particular line. If the subscriber required is at a private branch exchange the connector will find the first trunk to that exchange, but if that trunk be "busy" the contact with the busy tags will cause certain other changes to take place in the circuits so that the connector will now begin to hunt for an idle trunk.

Silk webbing of a special kind is used for multiplying the banks. The bank-switches are easily removed for repairs. They sit in a seat, and on top is a small bridge-piece, through the top of which a hollowed pin is dropped. The top of the switch is placed in the hollow and the pin then screwed to the bridge. This acts as top and bottom support. The top of the switch has a ring commutator, and these rings bear against springs, so that by this means circuit is made to the wipers. This is the same in all. The wipers have a flat spring bearing on them with a good pressure. The switches are turned with a power of about 5 lb. The wipers are reset as they pass by a shaft roller on the right-hand side near the cams, after having left the arc to return to normal. A special feature of the apparatus is that it has been designed so that there are no adjustments. The springs of the sequence switch—*i.e.*, the switch with the cams—may at odd times require adjusting, but even that is remote. Any switch can be removed in a few seconds and another inserted. The grade of manufacture is high.

This description has referred more particularly to the semi-automatic, but there is nothing to prevent the registers and senders from responding to impulses made by the subscriber just as they respond to the combinations set up by the operator on the keyboard.

This system is giving such satisfaction that the American Telephone and Telegraph Company has decided to establish two 10,000-line exchanges in the City of New York, and began more than a year ago to make the tools for the manufacture of the various parts.

The American Automatic Company's System.

The American Automatic Company, of Urbana, Ohio, have developed this system. They began in 1906. The invention dates back to 1903.

There are four or five small exchanges in operation. Broadly, the principles are not unlike those of the Strowger system, and the wipers have no vertical movements: they rotate horizontally. The calling-device is involved, and alterations are contemplated by the company. At present the dial may have to send in as many as fifty impulses, whereas other systems send in only ten as a maximum at a time. The final connectors are limited to fifty subscribers, as compared with a hundred on other systems.

This system was not seen by me, but from what is known it is not developed to the stage of giving service as quickly and satisfactorily as other systems.

The Siemens-Halske Automatic System.

This is practically the Strowger system. The rights to use the patents of the Automatic Electric Company, of Chicago, in Germany were purchased by the Siemens-Halske Company, of Berlin. The engineers of the Siemens-Halske Company disapproved of the Keith line-switch, considering that the plunger was unsatisfactory and uncertain in its action under certain conditions, and that as 100 lines were controlled by one master switch, which might fail, some change to improve these features was desirable. They accordingly developed a piece of apparatus which they style a "pre-selector" to take the place of the Keith line-switch. Each subscriber's line therefore has a "pre-selector," the function of which is to connect the subscriber's line over an idle trunk to a first selector. In some cases a second "pre-selector" is introduced between the first "pre-selector" and the first selector, as by so doing the number of first selectors, somewhat expensive pieces of apparatus, may be kept at a minimum.

The "pre-selector" has arms which rotate and make contact with terminals disposed at intervals around an arc. When an idle trunk is found it stops. Alternating current at twenty-five cycles per second is provided as power, so that the steps are rapid.

On the selectors as manufactured by the Automatic Electric Company the magnets and the springs operated by them are attached to the selector itself. The Siemens-Halske engineers have removed these from the selectors and assembled them together. The magnets, now called "relays," are placed on a frame prepared for them, and are fitted with a metal cover common to a number of them so as to exclude dust. The apparatus has also been adapted to work semi-automatic, and special impulse-sending machines are employed to transmit the impulses. The apparatus is constructed and finished in the most workmanlike manner.

Generally speaking, the semi-automatic operation is very similar to that of the North Auto-manual at Ashtabula, while the full automatic is practically the same as the Strowger with the mechanical modifications referred to.

At Amsterdam a semi-automatic equipment, supplied by Siemens-Halske, of 1,500 lines, was seen in operation. The equipment had been installed only a few months, and was the first semi-automatic in Europe. The service was stated to be quite satisfactory, and it was intended to add another 2,500 lines, which were expected to be in operation by May of this year. The apparatus was all of a first-class finish and appearance. The attendants were able to answer up to 500 calls per hour. The equipment for the operators was of the type by which the call is made to seek an idle operator.

There were three mechanics and a wire-chief attending at this exchange. It cannot be said that the service is ideal, although it may be, and is claimed to be, better than the service formerly given by manual. Working at a high rate operators are liable to repeat the numbers properly and strike them up improperly. Subscribers state that bells ring sometimes and there is no one at the telephone when they answer, and sometimes the conversation is cut off. It was noticed that calls came in during my presence there, and as they did not find an idle operator, owing to all being busy, they lit a lamp on what is called an "overflow" position. There was no person at that position, and two or three lamps were alight there for a few seconds until operators became idle, when the calls again sought the operators. This was a fault not of the system, but rather of the management.

There were no proper statistics of trouble available, as the system had been in operation only a few months. The calling-rate was not high per subscriber. The provision for connecting subscribers of a manual exchange and those of this exchange together were good, being almost purely mechanical. It would take too long to explain the method.

Altogether the impression formed was that it was quite possible to give a satisfactory service by the means adopted.

At Berlin the Siemens-Halske firm had an equipment of 500 in operation throughout their factory, which was, however, full automatic and gave every satisfaction. This, of course, was under the most expert control.

The German Post Office had a 100-line full-automatic board in position, 49 lines of which were in use. The engineer stated it gave entire satisfaction.

Munich, in Bavaria, has two full-automatic exchanges of this system, one at Haidhausen of about 2,000 lines, the other at Schwabing of about 3,000 lines. These were visited. They were accommodated in fine buildings, and the rooms allotted to the apparatus were large and contained space for considerable additional apparatus. The trimness, general cleanliness, and good quality and appearance of the room and apparatus were admirable. The floors were covered with linoleum, beeswaxed, and highly polished. These were the best-looking automatic exchanges that had been met.

The engineers are well satisfied with the system and its operation. The number of automatic lines is to be increased, and the policy is to introduce automatic throughout. It is expected that in a few years there will be 45,000 automatic telephones in use in Munich, and it has been estimated that the saving will then be about £50,000 per annum. There is a great desire to eliminate the operator. This desire was also voiced by prominent engineers in Berlin, and from what information could be obtained it seems also to exist at Vienna.

At Haidhausen there are two switchmen; one helper who takes the switching-section at night; one helper for general cleaning; one helper for information and trouble; two men learning; two men for main frame; three men for outside trouble. These men are paid salaries ranging from £120 to £55 per annum.

At Schwabing there are thirteen men. The number of men in Schwabing and Haidhausen is high for the size of the exchanges. The engineers state they could do with fewer, but the men were there when the installation was put in and they have been continued; besides, it is necessary to teach men, as more automatics are to come along. One man is practically continually going over the banks of the switches cleaning the levels with alcohol and a chamois cloth. This did not appeal to me, but if they have the time it is a safeguard against imperfect contacts. The need of this does not exist in the Western Electric Company's system. The speech is good over the circuits. These are all three-wire circuits, and not the more recent two-wire system.

The following is a statement of existing or proposed installations and additions in the German Empire:—

MUNICH, BAVARIA.

	Number of Lines.	Equipment in 1917: Lines.
Schwabing—		
First installation, 1909	2,500	
First extension, 1911	500	
Second extension (ordered)	800	
	3,800	5,000
Haidhausen—		
First installation, 1910	1,500	
First extension, 1911	500	
Second extension (ordered)	400	
	2,400	5,000
Residenzplatz—		
Magneto equipment to be replaced by automatic equipment (ordered)	8,000	10,000
Balmhof—		
Magneto equipment to be replaced by automatic equipment (not yet ordered)	..	10,000
Three new suburban exchanges, each equipped for	5,000	
will be erected in the near future		15,000
Munich will have in 1917 a total equipment of		45,000 lines.

Population of Munich, 600,000.

Town.	Year installed.	Lines.
Altenburg, Saxony (first installation)	1910	800
Hildersheim (first installation)	1910	1,200
Dresden, Saxony (ordered 1911)	..	17,000
Posen, Prussia (ordered 1911)	..	3,000
Dallmin (first installation)	1909	30

Durkheim, New Dietendorff, Dornap, and Haeren ordered about thirty to forty each.

Automatic private branch exchanges ordered or installed :—

Name of Firm.	Number of Instruments.
Lauchhammer	50
Rote Erde	120
Breslauer	120
Berliner Bank	170
Zeuss (Jena)	300
Laverkusen	400
Krupp (Essen)	800

Siemens and Halske have in their works, Berlin, 500, and will extend this to 1,000 lines.

Now that the Western Electric Company has come forward with a semi-automatic system its attitude towards automatics generally may be gauged when it is noted that it has quite recently purchased the Lorimer automatic patents for £135,400.

It can be considered that henceforth the use of automatic equipment will increase. It will be some time before manual common-battery equipment will be considered obsolete, but surveying the whole situation one is driven to the conclusion that its decline has begun, and that in a few years its use will be but little entertained for new work.

There are some considerations in connection with the installation of telephone exchanges in our cities and throughout the country to which it seems appropriate to refer here.

It is generally said that a Government Department cannot or does not run any particular business in which it is engaged in the same businesslike way and with the same regard for and success in attaining economy that attends private enterprise in corresponding undertakings. It is not my intention to discuss whether this is so or not. There does not appear to be any reason why a Government Department should not conduct undertakings as satisfactorily as private enterprise. The development of the telephone system in this Dominion is, however, small as compared with what obtains where it is carried on by companies and where there is competition. If the Government has a monopoly of the telephone system whereby competition is not operating to bring about the development that its exercise in other countries brings about, it seems reasonable to assume that the possession of the monopoly carries with it the duty to leave nothing undone to secure that the use of the telephone shall be as widespread as it is where the freedom to engage in telephone business by private companies promotes not only the growth of the use of the telephone, but, as a consequence, the very highest development in methods of service.

We are about a million of people and have about forty thousand telephones in operation. To compare that with the following will be interesting—

	Population.	Telephones.	Inhabitants per Telephone.
Dayton, Ohio	123,000	10,500	11·8
Salt Lake City	101,000	13,350	7·5
Des Moines, U.S.A.	87,000	14,000	6·2
Houston, Texas	90,000	12,600	7·1
Los Angeles	330,000	82,000	4·0
Chicago..	2,500,000	300,000	8·3
Kansas City	350,000	55,000	6·3
Stockholm	350,000	73,000	4·9

Several of these cities are of about the same population as our principal cities, but observe the difference in development. Even in comparatively small towns there is high development.

Champaign, Illinois, with 20,000 population, has 4,000 telephones, mostly automatic; Decatur, 35,000, has about 6,500 telephones. These small places may be said to be typical of others, and charge about £6 10s. to £7 for business and £5 for residence. The medium-sized places have a higher rate for business, but usually a moderate rate for residence. The large places have usually measured rate, and also give a flat rate, which is high. Most places provide for party lines at intermediate rates. Party lines range from quite small percentages up to 60 per cent. of the total telephone development.

It is a characteristic of telephone service that as the number of telephones increases the cost of operation and of installation increases. This is due to the greater complication that is necessary to arrange for prompt connection of one subscriber with another. This feature is less marked where service is effected by automatics than it is in manual methods.

It must also be borne in mind that a telephone service covering a large area is more costly per telephone than service in smaller areas, and that the larger the number of subscribers that are available and the area over which they extend the greater is the value of telephone service to each subscriber. Thus it is that in comparing rates, and also in determining them, consideration has to be given to these matters and to the question of special difficulties or expense that may be involved in reaching particular localities in any telephone-area.

Rates and development react upon each other. If the rate is low and common throughout an extended area considerable development may be expected to result, but this may so enhance the cost of providing each telephone that a loss is produced, and business that is to result in loss is not worth pursuing. When the development has resulted the value of the telephone to each subscriber may now be greater that it was formerly, owing to the large number of persons that can be reached, and each should pay more: but it is difficult, if not impossible, to raise rates under Governmental control. The reaction of rate and development thus becomes obvious, and it is necessary to be extremely careful to set out with a rate that is likely to meet both conditions.

Rates that will pay in one telephone-area may not in another, according as the areas are congested, or scattered, or have special difficulties such as waterways to be passed over. Hence it is that in the United States the rates are scarcely alike in any two cities. Competition keeps them below the point of paying legitimate profits in some cases. In other cases the rates are as high as the business will stand without inviting competition, and in yet other cases they are lower or higher than the average according to the smaller or larger capital expenditure that may be found to be necessary to provide telephones within the area.

It is assumed that we desire development and that it should proceed along business lines. This implies due provision for interest and depreciation of apparatus and plant on a basis that will meet not only the wear-and-tear, but also any obsolescence that may result due to changes in the art. This has its effect upon the rate, because money for these purposes must be earned, and this modification in the rate will again reflect itself upon the development.

There is no doubt that the measured rate is the correct principle upon which to charge for telephone service. It amounts to charging each subscriber some fixed sum for the apparatus and plant necessary to provide telephone service to each, and a charge besides for the wear-and-tear and attendance according to the use made by each subscriber, and also to provide the margin required for depreciation, interest, &c. Each subscriber should have as much concern about others having service as he has for himself, because subscribers are necessary to service being given at all. Measured service keeps down frivolous conversations, reduces the frequency with which subscribers are given "Busy," and thus expedites business. It also keeps the capital cost of the apparatus down, as less is required to carry on the legitimate telephone service of the community. This limitation of the plant enables it to be accommodated in smaller buildings, and the operating staff is prevented from growing out of proportion to the revenue produced, because increase of talk with a flat rate does not signify a larger income.

These elements have more effect in manual than in automatic methods, which are the more suitable for flat-rate service, but all our equipment of whatever kind should be ready to allow of measured service being undertaken at any time. In the meantime, it is necessary to be chary with the rate until some notion of the extent of development, the area over which it will occur, and the difficulties of accomplishing it have been arrived at. Whether our rates, with automatic method of operation, if made applicable to what may be expected to be our areas, are likely to produce results that will be satisfactory cannot be definitely stated until a suitable study has been made.

It is sometimes assumed that a telephone exchange can be put down almost anywhere and subscribers connected to it. This is quite erroneous, and not in keeping with recognized engineering methods. Probably two-thirds of the total capital cost to give telephone service has to be expended in plant outside and between offices, and it is necessary to so locate the exchanges as to keep this plant at a minimum. This necessitates a careful study and a weighing of the costs that will be incidental to locating exchanges at the theoretical centres against those of departing to some extent from these centres so as to make use of sites and premises that may exist already. To this end development studies are called for to determine where the subscribers will be, not necessarily at the time of opening an exchange, but during the process of development, so that the most suitable location may be chosen to keep the capital costs and the annual charges for outside plant at a minimum and to most easily serve them.

These development studies are a prominent feature of the American Telephone and Telegraph Company's methods. Indeed, no works are undertaken without them, and they are being continually made for fifteen to twenty years ahead, and being revised every three to five years in the light of actual happenings and having regard to changes that may be found to be taking place in the art. Although these studies have to be largely what may be styled an "intelligent guess," it has been found that the various data that can be gathered enable so good a judgment to be formed of what may be expected that the results are highly satisfactory.

These studies are not made by the technical or engineering branch, but by the commercial branch, whose officers, of course, have considerable technical knowledge as a result of being long engaged on such work and of being associated with the technical officers. When the study by the commercial branch is completed it is handed over to the engineering staff to carry out. The organization consists of commercial, traffic, and plant engineers. These are closely associated, and as far as possible have rooms so that they may freely meet and confer, and no action is taken by any one upon any matter that may affect the methods or works to be cared for by the others without advising them. Conferences between them are frequent, and even conferences of the officers of these branches from neighbouring and sometimes remote cities or companies take place from time to time.

It is not to be expected that our development studies can at first attain an accuracy corresponding to that referred to, but a beginning has to be made, and it may fairly be claimed that we shall be able to decide where exchanges should be placed much better after such a study than without it.

To do these works staff is required. Our engineering staffs are not nearly sufficiently manned. As outlined, the works contemplated call for a staff of Head Office engineers, whose duty it would be to

keep abreast of the times in respect of developments, who would determine means to be applied to attain ends, and who would be able to give information to engineers outside; and conferences should take place from time to time, so that each may profit by the knowledge and experience of the other for the general well-being of the service. This staff would include commercial, traffic, and plant men, and it may, of course, be practicable to embody dual duties in the one officer if it were not found necessary or practicable to have responsible officers for each.

There would also be required local, technical, and commercial engineers to carry out works and collect and record data. It may be urged against this that it shows a tendency to load up with engineers, but it will surely be recognized that it is essential that important works involving large outlay should be well considered and thought-out before being undertaken. Engineering is slow work. Oftentimes there are no rules for guidance, and the " cut and try " method has to be adopted, which takes time with but little to show for it.

Other matters that would claim the attention of such a staff are the determination in terms of standard cable of various pieces of apparatus that are used on circuits (such as coils that have to be spoken through, induction coils, repeating-coils), leaks on circuits, the effect of condensers, and the like. In other Administrations and companies careful experiments are made, and somewhat elaborate testing methods adopted, to ascertain the speaking-value of circuits, and what the effect is of various combinations of circuits which bring into operation different apparatus, and how the apparatus affects them. This gives first-hand knowledge as to what is to be expected in certain circumstances, and enables provision to be made accordingly. Our Department is growing rapidly, and it is desirable that we should have the facilities, both of appliances and acquaintance with their use, to determine matters of the kind referred to experimentally, and not to be obliged to use apparatus that may be more or less suitable, merely because it is being or has been used elsewhere for a corresponding purpose.

Telephone service is a serious business. It cannot be treated as one subordinate in any degree to any other branch of a general service of which it may be a part. Wherever the telephone has attained any considerable development and is giving satisfaction, it will be found that these results have proceeded from the alert and watchful commercial knowledge and guidance that are continually exercised, and the technical skill and attention to detail given by engineers and officers whose sole duty it is to devise, and to give effect to the best methods applicable to the particular system being used, and to keep the apparatus operating at its highest efficiency.

From the considerations set forth it is recommended,—

(1.) That the more extended use of the telephone generally should be promoted as far as possible. The development of the telephone in centres of population in the Dominion as compared with that in many other parts of the world is low.

(2.) That the full-automatic system of giving telephone service be adopted for Auckland, Christchurch, Dunedin, and Wellington.

(3.) That the full-automatic system be adopted also for any exchanges at smaller places that may be requiring new equipment, in all cases where after a study of the conditions it may be found that the operation and economic features, and the general advantage to the public in respect of the character of the service given, would justify it.

(4.) That the Western Electric Company, London; Messrs. Siemens Bros., London, who supply the Siemens-Halske system; and the Automatic Electric Company, Chicago, who supply the Strowger system, be invited to tender for a full-automatic equipment for Wellington.

(5.) That studies be made of the four large cities to obtain some idea of what may be the expected telephone development in each, whether it is likely that it will be general throughout an area or more congested in particular parts of the area, and whether any particular parts will be specially difficult and therefore expensive to reach.

(6.) That the question of multi-office or satellite exchanges for the larger places be considered in their economic aspect as compared with giving service from, say, two or three exchanges in the area.

(7.) That, as development must to a considerable extent depend upon rates, the rate question be considered after the development study, so that, if necessary, a scale of rates may be drawn up that will promote development, be a reasonable charge for the area available, and provide reasonably for interest and depreciation of the plant and apparatus.

(8.) That suitable appliances be obtained for determining the effect upon speech of apparatus that must be introduced into telephone circuits, and for enabling the results that may be expected from combinations of circuits which introduce varied kinds and quantities of apparatus to be definitely known.

(9.) That the technical staff be increased as necessary to give effect to the foregoing, and to cope with expected developments.

Manual, Magneto, and Common-battery Telephony.

In dealing with this system it is considered that particulars of one or two exchanges will convey a good idea of general methods and procedure. Where anything calling for special remark has been noticed it will be taken up later and some comment made upon particular features such as opals, order wires, junctions, multiples, toll-working, and so on.

The first exchange visited was the main exchange in Bush Street, San Francisco. The lead cables, 400 and 600 pairs, come up from underground so as to attach to the main frame. The paper cables come in iron pipes passed through the basement-floor about 2 ft. apart. The silk- and cotton-covered lead cable, as leads to the main frame, is joined on here. The pothead is large—about 2 ft. 6 in. long and 5½ in. in diameter. Four or six 100-pair lead cables are all joined in one pothead, filled and wiped. The cables then pass out of the basement upwards and to the main frame, where they are fanned out. There are three exchanges and a toll-board in the building, but only

one main frame for all. Each exchange has a capacity of 9,600 lines. Each vertical of the main frame will accommodate 400 metallic circuits. There are no fuses on the main frame. These either are unnecessary, according to where lines come from, or are provided at pole-boxes at the distant end of the cables. Heat-coils are used, but in some classes of circuits, such as trunks, there are none. Wiring and jumpering is all very neat, and the wires where fanned out are treated with shellac. Dust is not allowed to accumulate anywhere. From the horizontal side of the main frame, which is of Western Electric Company's manufacture, the wires are run in switchboard cabling to the horizontal side of the intermediate frames, of which there are several, and then neatly jumpered to the vertical side. Cables to the switchboard are then taken out, bound together with linen thread in a suitable manner in the various iron runways, to the multiple, to answering-jacks, relay-racks, meter-racks, coil-racks, and condenser-racks. The neatness and cleanliness of everything are particularly striking, and these were features that were prominent throughout the United States and in the national telephone system in England. The main frame is all in one run, about 120 ft. long, and there is room for the addition of more verticals. The intermediate frames are broken so as to provide one for each exchange. Other frames are placed suitably relatively to the intermediate frames. The room is 16 ft. or 17 ft. high.

The usual fuse-boards, power-boards, battery charging-dynamo, and ringing-machines are provided. The wire-chief's desk is equipped for four or five positions. A motor supplied from the city current drives the charging-dynamo—1,000 amperes are used in the exchanges as discharge current. There is a gas-engine as a standby for driving a separate emergency dynamo.

Ringers are driven from the city supply or from the storage battery. There is also a small motor driving two small dynamos, one giving positive and the other negative current, for the collection or rejection of nickels when pay-stations are used. The ringers give the different tone tests, such as "Busy, back," "Don't answer," "Out of order."

A large gas-engine and motor plant is installed for working air appliances, so as to provide for the tubes for carrying tickets, and for general toll transfers upstairs.

There are six exchanges in the city, and also exchanges across the bay at Alameda, Oaklands, and Berkeley.

There is a fine large luncheon and retiring room, a portion of which at one end is screened off to be used as a hospital when necessary. This room is on the third floor, and will shortly be used as the position for a fourth exchange of 9,600 lines. At one end there is a cafeteria. Girls give their orders for food on a ticket, get it at cost price, and pay at the end of the month. The room is about 40 ft. by 80 ft.

In the toll operating-room there are ten recording positions. For toll-work proper there are thirty positions, with a calculagraph between each two positions. Seven or eight pairs of cords are used at each position. The different exchanges are designated by cards on the multiple field along the face of the board.

The number of toll lines assigned to each operator varies, but all tolls are multipled so as to increase team-working. The whole is laid out on practically a "no waiting" or "no delay" basis. It was observed that the girls were very smart.

As there are several exchanges in the city and adjoining cities across the bay, but only one "toll" or "long-distance" exchange, calls for long distance have to come from the A boards of the several exchanges through the ougtoing trunks to the "record positions." A ticket is here made out, and the subscriber advised that the operator will call him. Meantime the ticket is timed and put in an air carrier, which takes it quickly to a special position. These air carriers all lead to one "receiver" at the special position. The operators at the toll-boards have also air carriers to and from this special position. The arrival of a ticket through these air carriers causes a lamp to light to attract attention. The ticket is then removed. At the toll-board the subscriber's line is held so that no other subscriber can get him—*i.e.*, a test is put on his line and kept there for a period, say, up to five or six minutes. Of course, if he wants the line himself he can have it. When the toll line required is got the subscriber is rung and the connection put through. The two supervisory lamps enable control to be kept by the operator. The time of the beginning and ending of the conversation is watched, and calculagraph impressions taken on the ticket. There is no checking to the distant station, no recording in any way of incoming calls. All writing is kept down as much as possible. Operators are engaged on costly circuits, and the object aimed at is to keep the wires busy with legitimate work and the operators free to devote attention to seeing that conversations are expedited in every way.

On receiving a call at "record" a ticket is made out and passed away through air carriers to the special position already referred to. Here it is examined and dropped into an air-slot which conveys it quickly to the proper toll position, a lamp lights, the ticket is removed, and the connection made as soon as possible. Subscribers are taken up through trunks back to the B boards. This trunk has been arranged between B and record board, and when the record passes away the ticket the attendant also "order-wires" the toll-board where the subscriber's line is held until the ticket arrives from the special position. This is done by the toll-board operator taking up the subscriber on the multiple on her board of the trunk assigned at the "record position" to the B operator of the exchange at which the subscriber is. The toll-board operator must ring the subscriber back. On completion of the conversation the toll operator puts the card into the slot conveyor or air carrier, and it is taken back to the special position. There it is examined, and, if chargeable, passed into a tray beside the air receiver; if not chargeable it is passed to another girl for further treatment. Tickets passed into the tray are at once dealt with. There are enough tickets arriving in the day busy hours to keep two girls employed here. They complete the forms and sort them into pigeon-holes just in front of them. The forms are next day sent on to the accountant to be further dealt with. Any inquiry about the cost of a connection immediately after it has been made causes no confusion, as in a minute or less it is in its proper place in the pigeon-hole, and is easily found.

There is no difficulty in connecting one toll line to another, as all are multipled. No record is kept of this work.

On some long toll lines, such as that to Los Angeles, a telegraph is superimposed, and everything is arranged for the next connection, so that there is no waiting or loss of time on valuable long-distance wires. The operator sits at a position of the board where the set of telegraph instruments is fitted. This method is falling into disuse. It is not used in the States or in England nearly so much now as formerly.

A special feature in San Francisco not seen anywhere else, and one which has certainly much to commend it for large multi-office areas, is that of a clock with a lamp below it. The object of the clock is to have uniform time all over the area, and to enable time to be easily got by operators. Any operator by pressing a key marked "Tm" (and these keys are fitted amongst the order-wires keys at all exchanges) can get time. A girl sits before the clock and every few seconds speaks the time, and changes only at half-minutes: thus she says "4.7, 4.7, 4.7, 4.7"; then "4.7½, 4.7½," and so on. As long as the lamp is alight she keeps talking, as that indicates some person has the key depressed. When the lamp is dark she need not speak. It is found that the lamp is alight forty-nine minutes per hour. There are no errors of parallax in reading clocks, as this means obviates them. There is a telegraph-office, and several circuits are working. Not much work is done, and it is merely to comply with the terms of the franchise, which require telegraphy to be conducted as well as telephony. In a separate room a woman is keeping observation on the operating, noting time and generally acting as a detective over features that it may be desirable to know and to check.

In a small room apart was a three-position board of special subscribers, such as grocers and merchants. They work amongst each other and do not use the ordinary exchange, as they more readily get those whom they chiefly want. It occurred to me that this was an admission on the part of manual of weakness in giving connections promptly. It was stated, however, that this board was to be discontinued shortly.

In the same building on the fourth and fifth floors are two large exchanges, and on the sixth floor a smaller one. Each has B boards. The multiples of subscribers' lines are on the B boards. There are no multiples on the A boards. The most of the switching is done to other exchanges, and it is found more economical to work B boards and to discard multiples on the A boards when the switching is over 70 to 75 per cent. of the total connections. Ringing on the B boards is keyless. There are about forty single plugs and cords on which the trunks terminate.

On the A boards different numbers of subscribers per position are allotted according to the class of work to be dealt with. The party lines or nickel lines are not "metered." There is only one key for ringing and listening. Some positions where nickels are dealt with have two keys with each cord circuit—one to return the nickel, the other to collect. They are coloured red and black. The boards are all eight-panel. The A boards have seventeen pairs of cords on some positions, fewer on others. Every six panels they have the multiples of the outgoing trunks.

The answering jacks and lamps are also repeated in the multiple field to some extent, to aid reaching and to promote team-working. This is done in other places also. It is claimed that this improves speed of answering about 6 per cent. for one set of "ancillary" jacks, as they are called, and 9 per cent. for two sets.

Order-wires are numerous for the different purposes of prompt communication with attendants at other exchanges. The operator at any of these exchanges cannot connect a subscriber direct to another on the same exchange. The services of a second operator, known as the "B" operator, have to be utilized. The "A" operator on getting a demand for a connection "order-wires" the "B" operator either in her own or a distant exchange. In her own exchange the "B" operator is usually just across the room. The "B" operator assigns a trunk and the "A" operator plugs into that. When keyless ringing is used on the B boards the called subscriber's telephone continues to ring until the receiver is taken down to answer the call. That act automatically cuts off the ringing. The usual supervisory lamps are provided. The "B" supervisory lamp is dark until the "A" operator clears, the "B" lamp then lights and the "B" operator clears.

All calls are registered. Even ineffective calls are registered, but the operator fills a ticket for rebate to be made in such cases. The rebate is attended to when the accounts are being made up.

Operators fill a ticket in connection with "busy" calls, and endeavour to complete such calls as soon as possible. This is general in telephone exchanges where the measured rate is used.

"A" operators also fill up a ticket in connection with "toll" calls across the harbour to Oaklands, Berkeley, and Alameda, for which a charge of 15 cents. is made. These "toll" calls should be distinguished from "long-distance" calls, which latter term is more applicable to calls over a considerable distance. There is such demand for speech between the cities on each side of the harbour that it would be slow and costly work to handle calls in the usual "long-distance" manner. It is arranged that when subscribers ask for numbers upon which a toll is chargeable, the "A" operator makes the connection in the usual way, but she fills up a ticket and gets the time of the commencement of the conversation by pressing the "time" key already referred to. She has to closely supervise so as to get the correct time of termination of the talk also, but she is expected to do this in respect of all conversations to be able to "cut off" promptly, so it is not considered much extra burden to do this business in this way, beyond the loss of time over the ticket. All tickets are kept small, and the particulars to be filled in reduced to a minimum. Although this may reduce the total number of calls per day per position, and necessitate a few more "A" positions, it is calculated that this method is cheaper than having special positions, and the connections are made with much more satisfaction to the subscribers.

A corresponding method was found to be in use in several other places, such as Chicago to Milwaukee, Chicago to neighbouring exchanges on the outskirts of the city, New York to Philadelphia, and *vice versa* in each case.

The sections of the switchboard are lighted mostly with lamps and reflectors laid in a metal piece extending the full length of the boards and placed well up and forward of the cornice. Alternate lamps are on different switches. The head receivers are light. Breastplate equipments are supplied. The boards are all of the Western Electric Company's manufacture. There are good metal foot-rests and strong chairs. The incoming and outgoing of all employees are registered by a "time clock." There are 140, 130, and 45 women in the three local exchanges referred to, and 50 in the toll-board exchange. The rooms are all large, about 14 ft. or 15 ft. high, tinted light-green. The light is not great, but enough.

The Kearney exchange was visited. It is a fine plain brick building of three stories. The basement is of ample room and floored with concrete. There was great activity here, as men were engaged forming cables for alterations going on upstairs—viz., the introduction of keyless ringing on the B boards. Partitioned off was a gas-engine with a 10 ft. drive. It was about 30 horse-power, and had two large fly-wheels. The dynamo was delivering 500 amperes: 300 amperes were charging the battery, and the rest were working into the exchange. It is quite usual here to run the dynamo for working the exchange and for charging cells at the same time. There is no noise in the receivers. This was tried and found to be so. When the battery is full they float it on the dynamo.

There are two exchanges in this building on the same floor—*i.e.*, the top floor. These are for 9,600 lines each. One is full, the other has 7,200 connections. There are about forty or fifty A positions, not so many B. The largest A board here has the multiple. It is found, however, that the trunking is over 75 per cent.—more nearly ninety per cent.—and the A board multiple is not much used; or, in other words, there is not much direct connecting of one subscriber to another. The community of interest between them is small. It is the intention to remove the multiples from the A positions. It is pertinent to remark here that this feature, and what was seen also in London in one or two exchanges where provision was made for ringing all over the boards with party-line keys, and no party lines developed, show that it is difficult sometimes for the most skilled engineers to gauge just what is the proper thing to do in certain circumstances. The second A board has no multiples.

The room is about 60 ft. wide, 120 ft. to 130 ft. long, 15 ft. or 16 ft. high. It is lit from the top: there are also side windows. The room is tinted light-green and is well ventilated. There are 16 ft. between the backs of chairs where the A and the B boards run in parallel lines. All toll-work is done from the Bush Street exchanges. Demands are passed along to the record positions there.

Different sections on the A boards have different classes of service and different numbers of subscribers to attend to. Even the equipment of the sections varies according to the class of service being handled. Prepayment—that is, by nickels—and post payment—as in the case of Baird pay-stations—are taken at one place, measured service at another, and so on. Seventeen pairs of cords per position are used, and the cords are not reinforced in any way. They are not spiralled tips, but are screwed at the back of the board, and this feature may be said to be universal. Cleanliness and neatness prevail. A light canvas cover extends the full length of the back of the board over the cabling. Cabling-platforms are all iron: this is to reduce the risk of fire spreading. Water is always conveniently accessible in buckets. Sand is available downstairs; also chemicals. Fire-alarms are provided.

There are 166 girls for operating, and more are required. As far as possible they are used as two separate staffs for each exchange. A girl is borrowed at times. There is competition between all the exchanges in the San Francisco–Oaklands area, and keen rivalry exists as to which does the best work. A system of listening-in and observation of work is carried out, and from the results a summary is made as to the merit of the work. This summary is sent to all the exchanges every month, so that each sees how all are doing. A good deal of change takes place in the staff owing to girls marrying. Of the 166 girls about fourteen are floating—to cover sickness, absences, &c., but not including annual leave. This number was said to be insufficient, and twelve more were being asked for. Supervisors, monitors, complaint, information, and such like desk operators are included.

The girls get the national holidays as far as possible. They work at night. There are no male operators, and there are no men dealing with any business in the switchroom beyond those working at the mechanical features of the board. The girls get a week's leave each year with pay, and further leave may be arranged without it for special reasons when the business or number of girls will permit. It is said seldom to permit. It was stated that there is less sickness in these exchanges than in some others. Girls work eight hours. The hours of attendance are mostly broken, but are limited by a law, operative since June last, to forty-eight hours a week. The work is heavy from 7.30 a.m. to about 9.30 a.m., gradually dropping up to 10.30 a.m. Business remains slackened until 6.30 p.m., when it becomes very heavy until 8.30 p.m. This is explained by the district being residential.

The retiring-room, used also as a dining-room, is large. A matron is in charge of the kitchen. The bill of fare is liberal and varied. Only the actual cost of food is charged. There are eighteen matrons for the different exchanges in San Francisco for the luncheon undertaking. The greater number of the operators live at home, and their average length of service is thirty months. Throughout San Francisco and Oaklands girls start at 4s. 2d. a day, and in ten years can get 2 dollars 10 cents, or 8s. 9d., a day, maximum; average, about 6s. 6d. a day. Supervisors reach 2 dollars 60 cents, or 10s. 10d., a day.

The cables come in from underground and pass up through iron pipes, and are potheaded and taken away in four or six separate 100-pair silk- and cotton-covered lead cable, according as the underground cable is 400 or 600 pairs. The potheads stand vertically. One main frame does for both exchanges. The frames, meters, coil and condenser racks are all suitably disposed and of the Western Electric Company's pattern. The keyless ringing apparatus being added is really a relay arrangement by which the ringing is placed on the line by the insertion of the plug in the jack, and on the receiver being taken up by the called party the increase of current resulting operates the relay so that the ringing is cut off.

The plant engineer's office is in this building. He stated there is very little main-duct cable under 400 pairs run underground. This is subscribers' and not trunk cable. The gauge is No. 22 B. and S., weighing about 9½ lb. a single mile, and having a resistance of about 190 ohms per loop mile. The exchanges are not far apart and the subscribers' loops are short. Trunk cables are No. 19 B. and S. loop, resistance about 90 ohms, capacity about 0·08 mutual. The lead sheath is about 125 mils. thick; 3 per cent. tin is used in the sheath to harden it so that it will better endure drawing and bending. Draws vary from 300 ft. to 500 ft., according to road requirements. Aerial cable is the same thickness and quality of lead as the underground. It is suspended by marlin, or by metal rings, heavily galvanized, placed about 2 ft. apart. When using the rings there is no noticeable action between the lead and the rings, and the lead is not affected by chafe in any way. This method is in use a good deal throughout the States by the Bell Companies, and is generally stated to be an improvement on former methods of suspension. There is not found to be much trouble from aerial or other cable. Still, faults occur. There is no air-drying apparatus used, and this method was not seen anywhere in the United States. The exchange employees localize, find the spot where the fault is, repair, and dry out with a brazier and with hot paraffin.

Distributing in blocks is often done by running cable underground to the edge of the block, and even into it, and then passing *unprotected* along the fences with reducing lead cables to the various spots. Faults occur in these unprotected cables, but it was a matter for consideration whether it was not more economical to take a few faults and attend to them as they arose than to expend considerable money for protection which might be unnecessary in most of the places where such cable was run. It is considered better to attend to faults as they occur, and experience shows they are not burdensome. The Automatic Company, in San Francisco, does the same thing, and it was noticed also in other places. No attempt is made to keep ducts or manholes watertight. Cables are often quite immersed owing to wet spells and manholes taking in water. The manholes sometimes have holes made in their top to aid or serve as ventilation for gases. It was remarked that if cables were drawn into ducts during a dry spell, and wet weather then came on, faults showed in the cables. To avoid this special care was taken in drawing the cables. The duct was preferred wet, as any weakness in the cable would be observed before it got into service, and it has not been found that acids or alkalies from the streets are troublesome. They are too diluted to injure. Ducts are mostly earthenware multiple type. There is no fall for drainage necessarily arranged for; the ducts may be on a dead level. Small surface roughnesses do not injure the cable. They may score it a little, but it is found to be of no consequence in practice. Sometimes, if the alignment of the duct is bad, the edge of one duct may fit badly to another and there may be a little drag. Even this is not a serious matter. Creosoted wood is now being used, laid direct in the ground, and is said to serve well. There is no sign of attack of the lead by acetic acid. This is cheap and satisfactory. Ducts have usually 3½ in. clear opening. Iron pipes have been and still are used where their use is cheaper than considerable excavation for other purposes. A close record is kept of the position, the depth, and the general relations of the ducts to the service and to impediments in their line of run.

Manholes are mostly of moulded concrete. They are of different sizes, but large ones are about 6 ft. or 7 ft. by 3 ft. 6 in. and about 5 ft. headroom. They are kept as close to the surface as possible, as digging costs money. For extending to the subscribers from poles the company uses twin copper-clad steel wire, about No. 17, rubber-insulated and braided. This is mechanically strong and light. Formerly No. 14 copper wire, insulated, was used.

There are submarine cables across the harbour to Oaklands. These are lead-covered paper-insulated cables, armoured with steel wires. One has seventy-eight pairs, others have twenty-eight pairs and seven pairs, making in all 140 pairs. These cables are fitted with loading-coils about half-way across at Goat Island. The seventy-eight pairs have some No. 13 and some No. 19 B. and S. gauge. They are not suitable for duplexing over. The No. 19 pairs are used to Oaklands and the heavier No. 13 are for reaching the long-distance aerial wires coming from the north to that side of the bay. The loading-coils are about 1,000 ft. out of the correct place for theoretically best results, but practically it does not make much difference, if any, in working. The distance to Oaklands is eight miles, but the cable is only four.

Between exchanges in the city, trunk cables are run containing No. 19 B. and S. pairs or 90-ohm loops. This secures that subscribers with 22-gauge wire when joined through trunks to "long distance" will have a good speaking circuit. Some of these distances require 4,300, 10,000, and 11,000 odd feet of underground trunk wires. The plant engineer at the time of our interview was planning on paper a scheme for a forty-pair line, the phantoms of which were to be transposed. Only some of these were to be brought into early use, but the whole scheme was to be laid out, and if variation became necessary in time revision would take place.

There were sixty men in the drafting-office dealing with such studies, and planning and recording. Everything goes on to plans as far as possible. A study is made of every block: the kind of house, the vacant sections, all go down. The expected growth in a certain period is considered, and in estimating underground duct and cable, and in determining upon sites for new exchanges, all the circumstances become factors to be reckoned with. Plans are made of the city, or of portions of it. As the constructing party erects poles or removes them, or runs underground work, particulars are taken, handed in, and all are recorded. Boxes at street-corners have their special features noted on the plan by some mark which has a special meaning. Details are sometimes entered in books, and information is tabulated so that the rough notes can be destroyed. Pole sizes are indicated in various ways by marks. Everything is organized, which makes for ease of reference and reduction of work ultimately. Four men are dealing only with the question of way-leaves. All this is typical of what is being done by other telephone companies, and implies staff to take care of so much detail.

Long-distance wires are usually of 435 lb., 300 lb., and 173 lb. copper wire per mile. No. 10, 173 lb., is mostly loaded. It is intended shortly to load the No. 8 wires, as it has quite lately been demonstrated that this can be done. Electrolysis from stray electric current is troublesome, and special tests are made every three months while the usual precautions of bonding are taken.

West exchange was visited. There is a school of instruction in operation here. The dining-room, library, and retiring-room is comfortable and large, and is used by students and operators. In a separate room students were being given oral lessons or lectures explanatory of the switchboard, the jacks, special markings, and so on. In the school switchboard-room is an A board for twelve positions, a B board for five positions, and a small two-position board which represents the distant station. Every method of operation that exists in any of the exchanges is to be found here, and the students are exercised in the various manipulations. It takes about three weeks to train an operator. There were about eight learning at the time of my visit. There are about three thousand applicants a year. The previous month 140 students passed through the school, and 116 were rejected, or failed to come, or did not proceed for different reasons. Great care is taken in selecting girls, who must be from seventeen to twenty-five years of age, 5 ft. 2 in. and over in height. Graduates are preferred.

As showing how necessary it is to make a toll charge when special circumstances exist, although the community of interest between two such places may be great, the traffic engineer instanced the charge of 7½d. for three minutes and 2½d. for each extra minute's conversation between San Francisco and the Oaklands side of the harbour. During 1910 the toll talks outwards numbered 1,116,488, and the revenue was 186,944 dollars, or £38,946. The average revenue per call was 8½d. The work and revenue from Oaklands side was about the same, or a total of about £77,892 for the year. This revenue would have all been lost if no toll were charged, while the demand for talk would be much greater than now, and would compel the use of more cables, which are expensive to supply and maintain. Switchboards, office-room, and operators would all have been required in increased proportion at both sides. If these charges were not met by tolls they would have had to be made by an increase on the general annual subscription.

As giving some idea of the staff troubles, it was stated that for San Francisco alone 499 girls resigned during the year, 15 per cent. were discharged, including 7 per cent. dropped for various reasons after entry to the school. The total number of girls in the San Francisco exchanges is 1,132, and on the Oaklands side 750. There is usually one supervisor to every eight or ten switchboard operators. When everything is straightforward each operator is expected to be able to handle 275 calls an hour. Each such call is considered a unit. With B boards and 100 per cent. trunking this is reduced 52 per cent. Different classes of service, such as coin-collecting and party lines, reduce the speed of operating, and all have to be specially considered in allotting loads and determining the number of switchboard positions. Coin work is always slow, as the operator has to speak to the subscriber, direct him as to coins, listen or watch for them, and collect or reject them. Some coin machines require prepayment—that is, the nickel must be inserted before the exchange can be got. In other cases the exchange is called, and when the operator directs the coins are dropped in, and the operator listens for the sound of the gong or other distinctive noise.

Trunks are found to be held for local conversations about two minutes. Social conversations average four and a half minutes, and are much longer than business talks.

During 1910 the exchange subscribers increased from 61,000 to 74,000, an increase of, roughly, 23 per cent. They were made up of—private branch exchange, 32 per cent.; four-party, 30 per cent.; one-party or individual line, 30 per cent.; two-party, 8 per cent. This indicates the party-service and private-branch exchanges to be material features of the increase. Four-party lines, while taken, are not liked, and the company is striving to raise the class of service taken by subscribers all over its territory, which is very large. There are about 480,000 subscribers.

In San Francisco, with 72,500 stations, there were 423,000 local calls a day, or a calling-rate of 5·7, and with 74,000 stations there were 32,500 lines. For private-branch exchanges the subscribers wire their own buildings—*i.e.*, they make a private contract with outsiders to do so. There are about 700 of these where operators are kept, and they are served by about 2,400 trunks, having connected to them 17,400 stations.

For all exchanges of over 2,000 stations the business stations are 40 per cent. and the residence 60 per cent. of the total.

For long-distance conversations the rate is based on six-tenths of a cent. a mile air line for one minute's conversation, subsequent minutes each 20 per cent. of the first minute.

Errors in the San Francisco exchanges were over 5 per cent. at the beginning of 1910; these were attacked, and at the end of the year the percentage was reduced to 2·1. These consisted of such matters as wrong numbers, cut off prematurely, wrong busy test, wrong party line. Errors of this kind are really serious, and, as is seen, can be kept down with proper handling. 2 per cent. of errors is very low, and in exchanges that are considered as giving fair service these errors run as high as 10 per cent. Operators' irregularities, such as answering improperly, not using proper terms, and cutting into circuit needlessly, are endured up to 15 per cent. These have been reduced very considerably. That only sixteen letter complaints were received in a month from 78,000 stations is a testimony to the kind of service given.

From 10 p.m. to 7 a.m. there are only forty people in attendance in all the San Francisco exchanges.

The following table is interesting. In the school at West exchange during 1910,—

	San Francisco.	Oaklands.
Students accepted	1,010	393
Students not accepted	1,311	315
Students resigned	145	78
Students discharged	184	30

Of 11,112 calls upon which observations were taken the average time of answering was 3·8 seconds; the connection was established in 16 seconds; the subscriber answered in 32 seconds; the average duration of the conversations was 105 seconds; disconnection was made after conversation finished in 3·1 seconds.

These are particularly good figures, and compare favourably with other places visited.

In Salt Lake City, with a poulation of about 100,000, the Rocky Mountain Telephone Company has a fine five-story brick building. The president's office and general staff offices are provided for in it. The exchange has about forty-five A positions. There are only two small outside exchanges, so the B board comprises a couple of sections at the end of the A board. About 125 girls are employed. The toll-board has four recording-positions and about a dozen operating-positions. "Information" and "complaint" positions are located in the toll-board room. There are six positions for information purposes, and four girls were listening and answering inquiries. They have twenty jacks each, and cards of particulars, and the latest directory amended. The amendments were made with different-coloured pencils, and each colour denotes something special, so that information is quickly given. Cords wear fairly; one-half are tested each night. The operators at the A boards and those at the toll-boards do not interchange. Toll-board operators are in some sense specialists. There is no second check on any toll-work: it is considered any such check would be wasting an operator's time and the line also. Switchings from one toll line to another are not recorded in any way.

This company operates over 413,000 square miles of territory in the States of Utah, Idaho, Montana, and Wyoming. Their area is four times that of New Zealand. The average depreciation over all kinds of plant apparatus is taken as 7 per cent. There are in Salt Lake City 6,106 lines; 9,520 paying subscribers; 2,841 extensions and P.B. exchanges; 4,678 business and 7,783 residence stations—total stations, 12,461. The average rental per month is 2 dollars 52 cents, or £6 6s., per annum. Each toll collection averaged 2s. 5d.

Private-branch exchanges are supplied with battery and ringing-over wires from the exchange. They have 227 lines so used. The rate is one and a third of that for an ordinary individual line, to cover the cost of the battery and ringing-pair. The rates within the city limits, about two miles and a half radius, are—individual business, flat rate, 78 dollars, or £16 9s., a year; individual residence, flat rate, thirty-six dollars, or £7 10s., a year; two-party residence, flat rate, 30 dollars, or £6 5s., a year; four-party residence, flat rate, 24 dollars, or £5, a year.

On private-branch exchange boards the charge is 18 dollars, or £3 15s., annually for each station up to ten; beyond ten the charge is 12 dollars, or £2 10s. The private-branch exchange board is provided and maintained by the company. The regular extension rate is £2 10s. per annum. Four-party lines are disliked by the company and by the people; it is only the price that commends itself to them. The maintenance is much more on this than on other classes of service, and the company is doing its utmost to curtail this class of service. The wages of linemen, such as wiring-men, installers, and inspectors, range from 90 to 110 dollars, or from £18 15s. to £22 18s. 4d., per month. Labourers or groundmen command about 10s. 6d. a day of nine hours. 225 calls per operator is the standard per hour expected to be handled. The trunking is low, as there are only two small outside exchanges in the city. Each operator can therefore complete almost the standard number of calls per hour. As there are only forty-four positions, the average lines per operator over the whole board is 138, while there are 283 stations on the average per position. The calling-rate per station is between six and seven. The work slackens off about 8.15 p.m. Eight female operators are in attendance all night. After 9.30 p.m. there is not a great deal doing.

Toll charges are made on a basis of 1 cent., or ½d. a mile, air-line, for three minutes. Over three minutes each minute is charged at one-third of the three-minute rate. Subscribers here or anywhere else in the States are not advised when the three minutes are up.

Girls' pay varies: Ordinary operators, 5d. to 8½d. an hour; in a few cases, 6d. to 10½d. an hour. The chief supervisor gets £10 8s. 4d. to £12 10s. a month. The chief operator gets £15 12s. 6d. a month. The average time of answering is 3 seconds; the disconnect average is 4 seconds; the slowest answer is 17 seconds; the percentage of calls answered in five seconds is 88·5 per cent. It is stated there are not more than twelve to fifteen complaints, written and verbal, a day.

The switchboard is of Western Electric Company's manufacture. The jacks and plugs are small, $\frac{5}{16}$ in.

The "Bell" development in this city is 7·5 persons per telephone. The Independent Company has 7,500 stations, so that the telephone development of the city is one for every five persons.

Chicago Telephone Company.

A couple of months prior to my visit to Chicago there had been a reorganization of "Bell" interests, which were made to include the States of Michigan, Indiana, Illinois, Wisconsin, and Ohio. The companies of these States are all separate, but the instructions, directions, and general control proceed from the head of the new organization.

There are thirty-five exchanges in Chicago. Some of the principal ones were visited. The first were those known as "Main" and "Franklin," for which there were eighty-six A positions and two B boards of thirty and twenty positions, all on the one floor. Besides these there is a sixteen-position local exchange board for the officers of the Chicago Telephone Company only. At the end of the A Board are two positions called "Hospital." These have no subscribers connected with them. The A and B operators have trunk connections extending to them. These operators have no time to deal with any calls presenting unusual features. Numbers improperly listed, numbers not listed, numbers changed or taken out, when asked for by subscribers, are all trunked away to "Hospital." These positions are used in this manner as it is found better to have a few girls with special knowledge looking after such matters than to have them imperfectly attended to. The trunking to "Hospital" lights lamps at those positions as in the case of subscribers' calls at ordinary positions.

There are various kinds of service given. For " commuted service " a subscriber pays 1 dollar, or 4s. 2d., a day, and speaks as frequently as he cares to. If he has other trunks he pays for their use £5 a year and 1d. for every outgoing call. The result is that subscribers keep their " commuted service " trunk as full as possible, and do as little as they can on the others.

There is an unlimited flat rate of 125 dollars, or £26 10s. 10d., a year. Of these only about forty lines per position are allotted, and only one subscriber on each line Another service is 60 dollars, or £12 10s., a year. 1,200 calls are given on one line ; over 1,200 and up to 3,600 are charged 1½d. each, and over 3,600, 1d. each.

Subscribers can contract for 7,200 calls a year. The company will give a switchboard and an extra trunk free, and for every 6,000 calls they give an extra trunk free ; or, having contracted for 7,200 calls, subscribers can have " commuted " trunks at 4s. 2d. a day and pay 1d. for each call. Sometimes an operator is allotted only twelve lines where there are " commuted " trunks, as many stations may be sending work in over them. The calling-rate per station varies from 10.3 to 3.5.

On the A and B positions and the local exchanges 200 girls are working at one time. The total number of operators and clerks of various kinds is 410, including those working on the express and toll boards. There are sixty positions for flat rate, twenty-six for measured service, and many for coin-collecting. Some coin positions are equipped so that the money can be refunded if the connection asked for is busy. At other positions the operator first gets the required subscriber and then requests that the money be deposited. This is known as the " nickel on request " method.

Private-branch exchanges remove their operators at certain hours, and these differ. There is a small special detached board on which buttons are arranged. Pressing a button puts on a tone test on the jacks of the trunks to the private-branch exchange, so that the operator on testing knows what to advise the calling party.

Cords are tested once a week, at night, but it is considered that the cords are continually under test in use as the girls are required to supervise. They must not listen-in needlessly, but they are expected to see that parties get through to each other. Generally there are seventeen pairs of cords. Ringing is on the front cord only. There is only one key for listening and ringing. Order-wires, supervisory lamps, and meter-keys, as usual, are fitted on the positions on which these are necessary. A feature in all these large exchanges that are close to the factory is that they can equip their boards for just the kind of service they find demand for. It takes comparatively short time to get supplied.

The " information " equipment is a flat switchboard with jacks, cords, &c. Women can stand on either side. There are about twelve positions, and seven were being worked at the time of my visit. The jacks and lamps are multipled so that any girl can attend to any call to save delay. The information is mostly got from the amended directory. The work is particularly trying towards the end of a directory period—there are so many changes. The directory is published every four months. This board cannot be called a good arrangement. It is intended to devise some better method.

There are small clocks in many places along the face of the A sections high up for operators to advise subscribers after a certain lapse of time that a subscriber called for does not answer. The management recognizes this method is not of much use, however, as girls are too busy to give this work much attention. It is done as far as possible.

Some subscribers are not given " toll " or " long-distance " service. To distinguish them special marks are placed on the opals of their calling-lamp. Any demand for " toll " coming on any such line is at once noticed by the operator and is declined or referred to a monitor. Other classes of service, such as measured, one, two, four party, and nickel services are indicated by marks on the opals of the lamps.

A lot of apparatus, such as relays, retardation coils and resistances, is placed at the back of the switchboard. This is found convenient, as where the several portions of apparatus are far apart much time is lost in testing and finding faults.

The " long-distance " work is done by the American Telephone and Telegraph Company. The sections require about a hundred operators to look after them. There is a " record " position in the room above, to which all requests for " long-distance " are transferred for ticket purposes. All tickets go by air-carriers to a distributing-centre, and are there examined and passed away to their respective positions. When the tickets are finally dealt with by the operators they are returned through air carriers to a special sorting-point, where any inquiries about charges are dealt with. " Long-distance " work is not subject to much delay. Most conversations are dealt with within ten minutes, the greater proportion in less.

If a demand comes over a long-distance line for connection to another long-distance line, as there are eight miles of underground wire from this building to a " long-distance " office at Morell Park on the outskirts, which would necessitate sixteen miles of underground cable being spoken through, to the marked detriment of speech, the operator merely presses a button : this gives a signal at the other office. The operator there plugs in, takes up, and completes the call clear of all cable. This is done in some other cities also.

Outgoing " long-distance " calls originate on tickets. The operator gets the required " long-distance " office and the person required there, and seeks the calling subscriber through the B operator.

As the work slackens they can close up sections until at night they have only three operators on duty.

There are two metallic circuits to New York. All wires are of 435 lb. per mile copper. The circuits are fitted with loading-coils and are phantomed—*i.e.*, a third telephone circuit is got over the top of the other two. These wires are also composited so that the telegraph can be worked on each wire at the same time as the circuits are being spoken over.

One of these wires is used for arranging for conversations on the telephone circuits. The charge is £1 0s. 10d. for three minutes—distance 950 miles. There are sixty pairs of wires to South Bend,

forty or fifty miles distant. There they branch in different directions. The telephone long-distance circuits are mostly composited and the telegraph leased to newspapers and others. Conversation is good, and remarkably free from cross-talk and Morse disturbances. There is a slight thud-like noise on some circuits, but it is not disturbing or irritating.

To Milwaukee (100 miles distant) there is an underground cable. The cable has 120 pairs for a considerable distance at each end and sixty pairs go the whole distance: these are No. 14 and 16 B and S. Loading-coils are used. The speech is good.

The number of operators in Chicago is 4,500. Of these 883 are in the exchanges being referred to. This number includes the American Telephone and Telegraph Company's long-distance force. There is a large dining-room. Meals are free, and cost the company about 4d. each. The total amounts to between £5,000 and £6,000 per annum. Girls' rest and retiring rooms are spacious and well aired.

In the school about 100 girls were receiving oral instruction. There are usually about 150 a month or 2,000 a year. In one year the whole staff of 4,500 was changed. The average length of service is twenty-two months. Girls between sixteen and thirty years are employed. Great care is exercised in choosing them. Each girl is reckoned to have cost 150 dollars, or £31 5s., before she is useful. Girls start in the school at 5 dollars, £1 0s. 10d., a week for a course of three or four weeks. They are then put to evening work, 5 to 10 p.m., and paid as for eight hours at 5½d. an hour for six months. They may get on the day staff, when they work eight hours and a half. All day staffs work eight hours and a half. This does not include half an hour for lunch, which is deducted. All girls get fifteen minutes relief in the morning and the same in the afternoon. Evening operators get fifteen minutes for lunch, say, between 6 and 7 p.m. After six months operators work three months at 6d. an hour, three months at 6½d., three at 7d., six at 7½d., six at 8½d., one year at 9d., one year at 9½d., three years at 10d., two years at 11d., and then 11½d. is the maximum. Supervisors get ½d. advance on what they may be drawing when promoted. Each three months they get ½d. increase. They work at 11d. for six months, at 11½d. for six months, and 1s. for a year.

There are day and night operators: they do not change. The A operator in the daytime is interchanged with the B operator to keep each familiar with the work. The night operators work from 10 p.m. to 7 a.m., and are paid for eight hours and a half. They get half an hour's rest about midnight, and later lie down for an hour.

Two exchanges, Central and Randolph, have 25,000 stations on 9,000 lines. There are 475 operators, of whom 325 are on at one time, 100 in the evening and 25 at night. There is only one residence station in these exchanges. There were forty-five absentee operators on the day these exchanges were visited. Randolph has sixty-two A positions and twenty-four B; Central has 104 A positions and thirty-six B. These two exchanges are in one large room, which was dark and the ceiling low, about 12 ft. Electric light was burning to give sufficient light. The atmosphere was not all it might be, and ozone was being used to improve it. There is plenty of floor-space.

A private-branch exchange at Marshall Fields has 16 A positions and more being added, and two B positions. To deal with the traffic to and from this private-branch exchange there were seventy outgoing and fifty-five incoming trunks at the Central exchange. The power plant, cells, racks, repeating-coils were of the Western Electric Company's usual type.

There were 253,000 stations in Chicago, and the increase of stations was at the rate of 40,000 a year.

At Detroit (population 450,000) the Independent Company has a plant of the Dean Company's manufacture. The switchboard is a fine-looking structure. The operating-room is large. The company has been four and a half years in business. It has five sub-offices and 16,000 stations. One of the sub-offices to this exchange is at Crest, three miles distant, and is working automatically with 10 per cent. of trunks to the main office. It is equipped for 300 lines, and is giving satisfaction. One man is attending to the equipment. 210 operators are employed: of these 105 are in the main exchange. The average pay of operators is 28 dollars, or £5 16s. 8d., a month. The operating staff is changed frequently. Operators get two weeks' instruction, and are paid 20 dollars, or £4 3s. 4d., a month while learning. There is a switchboard with twelve positions in the main switch-room: this is used for school purposes. Two instructors attend to operators who are learning. The B board has fourteen positions. Five positions on the A board are for pay-stations. The Gray nickel machine is used. The arrangement is that the operator gets the required subscriber and then asks that the money be deposited. The operator listens, and when she hears that the money has been paid she completes the connection.

Frequency four party ringing is employed, and gives every satisfaction. 40 volts are employed for speaking and signalling from the subscribers' stations.

Their long-distance lines are composited, and worked simplex and duplex by those who lease them. The battery for telegraphs is supplied by the Telephone Company up to 120 volts.

Some long-distance rates give an idea of their charges for that class of service: Seventy-five miles, 1s.; fifty miles, 7½d.; forty-five miles, 7½d.; thirty miles, 5d.; twenty-two miles, 5d.; seventy miles, 5d.: twenty miles, 5d.; twenty-five miles, 2½d. It will be seen that there is an absence of uniformity in mileage charges. These distances are to particular towns, and the rate has been made as has been found to suit the business. The subscribers' rates are, per month,—

	One-party Line.	Two-party Line.	Four-party Line.
	£ s. d.	£ s. d.	£ s. d.
Business	1 0 10	0 16 8	0 12 6
Residence	0 10 5	0 8 4	0 6 3

The cables are lead-sheathed, mostly underground, 200 and 300 pairs.

In New York long-distance exchange the arrangements for using the telephone-lines for telegraph circuits that are leased, both telephone and telegraph work proceeding simultaneously, form quite a feature. There are about 250 of these composited lines. All are fitted up as duplex, though most are worked simplex. Storage batteries are used, and voltages, not in excess of 120, that are suitable for the circuit. The lines take 50 milliamperes and more in bad weather. Relays are wound to 200 ohms, repeating-relays 250 ohms and sounders 20 ohms. Sounders are worked off 24-volts 400-amperes hours' storage battery. They take about one-third of an ampere. Lamps are inserted in the local circuit to keep down the current. There is a large number of testing-positions and men for attending to the different requirements. These men are paid more than operators—usually from £20 16s. 8d. to £22 18s. 4d. a month. They work nine hours a day.

There is very little noise on the composited circuits. Conversations to Boston, Chicago, and Washington were listened to, but only on the Chicago circuit was there any flattened Morse noise, and that was faint and not noticeable while talk was going on. Many circuits had to be plugged in on to find one that was giving trace of noise. In New York loops of local circuits are taken from the exchange to the lessee's premises. These loops pass through a coil differentially wound. When there is anything wrong the lessee presses a button, which puts an earth on and cuts out one of the differential windings. A shutter then drops at the testing-room, and attention is at once called and the difficulty remedied. The charge for these leased wires is usually about 20 dollars, or, roughly, £4, a mile. Wires are sometimes leased for certain hours of the day only.

To Philadelphia, ninety miles distant, there are underground lead-covered cables containing 116 pairs. These are run in an earthenware conduit. The pairs are paper-insulated, and are Nos. 13, 14, and 16 B. and S. They are not phantomed. There are also similar cables as far north as New-haven, seventy-five miles.

For long distance up to, say, 600 miles on composited aerial lines the telephone ringing is done in a special manner. The ordinary 16-cycle ringing works a relay at the home office, which brings in a high-frequency ringer by means of a slow-acting relay. This closes a contact at the distant end, which brings in the 16-cycle usual ringing at that end. "Ring off" is got by the operator releasing on the subscriber's signal, and then passing a signal to the far end.

Connections to Philadelphia are given on practically a "no-delay" basis. Thirty-three circuits of an underground cable are used by eight operators in the "busy hour." The load then varies from 180 to 190 calls. The work is done by order-wire. The distance is ninety miles, and the rate is equivalent to 3s. 1½d. The maximum delay is three minutes and a half, and most communications are connected through within a minute.

There are 350 girls engaged on long-distance work. This is the American Telephone and Telegraph staff. Their quarters are comfortable. There are dining-room, sitting-room, kitchen, and matrons. The girls are provided with milk, tea, and coffee free. They bring their own lunch. Eight hours constitutes a day's work. Wages are from 10 to 12 dollars, or about £2 to £2 10s., a week. "Information" is provided for at a special board to accommodate eight persons.

Battery-charging appliances, ringing-appliances, fuse-panels, main and other frames, coil, relay, and meter racks, &c., are all of the usual Western Electric type, and neatly wired, jumpered, and cabled. Great care is taken to keep all clear of dust. Men go over parts with cloths and also "blow out." Wires can be "ordered up," and the usual tone tests, observation of the operators and of the subscribers can all be applied.

The Cortland and Rector exchanges of the New York Telephone Company were visited. These two exchanges are in the same building. This company has its own toll-board apart from the "long-distance" board of the American Telephone and Telegraph Company for operating toll lines of 400 miles or so in its own territory. They record and pass tickets by tube to special positions, where they are, after examination, passed away to other positions by tube, to be distributed by girls to special places.

There is very little delay on toll-work. Everything here is on the "no-waiting" basis. Toll rates are high. New York and American people generally want to talk at once, so that many circuits have to be kept ready to meet the demand quickly at busy times.

The toll-board and local exchange staffs are kept quite separate. Each has its own retiring-rooms. There are day, evening, and night staffs: these are distinct, there being no rotation of day and night staffs. Operators are transferred when necessary from one staff to the other.

The lighting of these exchanges is by tungsten lamps with holophane shades. The reflector methods of lighting up the panels of switchboards is being generally abandoned. The rooms accommodating these exchanges are about 12 ft. high. Artificial ventilating is used to exhaust vitiated air.

Cortland exchange has multiples on the A, but they are not much used. Most of the calls are trunked. In both exchanges keyless ringing is used on the B boards. The cords on all positions are coloured red, white, and green, and the supervisory lamp-opals are of similar colour to correspond with the cords. This is to assist in tracing cords, so that they may be taken down more quickly at the conclusion of a conversation. There are no party lines. Cords are tested at night, but the girls in actual work are considered to be the best testers, as they should detect trouble in conversation and check the cords.

Ancillary answering-jacks are provided in the Rector exchange on the A board to aid team-working. These have been cut in on the cables at the back of the board, and well taped and insulated. On A boards there is different equipment on the key-shelf for the different classes of service, and similar kinds of service are gathered together. There are no "hospital" positions. The coloured buttons are inserted in every section.

The B operators are raised on a dais about 1 ft. high to enable them to reach the top multiples easily. In certain classes of work A operators have to make out a ticket. A red light warns operators of the ticket feature There are effective meter-keys where necessary; but ineffective meter-keys are not fitted anywhere. It was noticed that these operators, although well disciplined, often broke connections by pulling the cords instead of seizing the peg.

Observation circuits are kept active from 8 a.m. to 10 p.m., and on Sundays and holidays.

The hours of duty were shortened some time prior to my visit to New York. The actual duty at the switchboard of day and night operators has been altered from nine to eight hours, and of evening operators from eight to seven hours. For Sunday duty a day off was given during the week, and now a half-day's overtime is beng given in addition.

The maximum-wage scale for evening operators was increased 4s. 2d. a week, and for night operators 8s. 4d. a week. Operators enter the schools at £1 0s. 10d. a week, and are transferred to offices at the same wages. Those for evening and night work on transfer get £1 5s. and £1 9s. 2d. per week. Salaries are increased on the merit system, taking into consideration attendance and deportment.

Day hours are 7 a.m. to 7 p.m. The evening force is liable to broken duties ranging from 9 a.m. to 10 p.m. Night operators work 10 p.m. to 7 a.m. The day and evening force actually work eight hours per day. They receive half an hour for lunch, and fifteen minutes' rest during the morning and evening. All central office employees of less than three years' service receive one week's vacation with pay. If of more than three years' service they receive two weeks' vacation with pay.

Several other exchanges were visited in New York City, amongst them Riverside and Morningside, with about 7,000 lines each and 18,000 to 22,000 stations. These exchanges are similar to those already referred to. There is a large number of residence stations, and the calling-rate per station is low, so that each position has a large number of lines and stations allotted—200 to 250 lines and 570 to 600 stations. The neatness and cleanliness of everything were features that compelled notice everywhere.

A day was spent in the West Chester district, in the suburbs of New York, with the plant engineer of the New York Telephone Company, who gave me every facility for seeing several smaller exchanges and their aerial lines and cables. Three or four exchanges, of sizes varying from 1,000 to 2,400 lines, were looked at. All were found to be much on the same lines, and looked much simpler than the more involved central offices. The quality and style of the apparatus were similar in all. The buildings were all of brick, and every care was taken to assure the comfort of the employees.

It was seen that aerial lead-covered cable even up to 300 pairs was strung overhead. The spans are about 1½ to 2 chains long. These cables are mostly suspended by marline or by special metal rings, well galvanized, placed loosely on the bearer, and the cable drawn through them. These rings are not bound in any way and do not seem to move out of place. Wooden terminal boxes such as we use in New Zealand are employed where the larger cables are reduced to smaller ones to drop a number of pairs at any point.

The lead sheathing of these cables is from 100 to 125 mils. thick, and is mixed with 3 per cent. of tin, which is found to harden it and render it less liable to flatten on a short bend. Some of the underground work that is being undertaken in connection with the laying of cable between New York and Boston, about 250 miles, for telephone purposes, was seen. Earthenware multiple duct is used with about 3½-in.-square opening. This is laid on about 3 in. of concrete, and about 3 in. of concrete is placed on top. If the walls of the trench are sclid no concrete is placed on the sides, but if loose or friable the sides are also served with about 3 in. of concrete. The loading-coils are placed about every mile and a quarter. These coils are in strong metal cases like transformer cases. They are made watertight. In the manholes these cases are placed deep, and a false bottom put over them at about the usual manhole depth so as to facilitate the cable-jointing and general handling.

Some time was spent with different officers of the American Telephone and Telegraph Company and of the New York Telephone Company looking into and discussing various aspects of the telephone situation.

In New York the rates are most varied. In Manhattan and Bronx, which are message rate districts, the following rates prevail: For a direct line—600 calls free, £10 per annum; 2½d. each additional message. Business or residence—1,800 calls free, £20 12s. 6d. per annum; 2½d. each additional message. Two-party lines—600 calls free, £8 15s. per annum; 2½d. each additional message. Business and residence—1,000 calls free, £12 10s. per annum; 2½d. each additional message: 1,500 calls free, £16 5s. per annum; 2½d. each additional message. Monthly payments are provided for. There are many other rates, such as extensions, short-term contracts, season contracts, interior systems, private-branch exchanges, farmers' lines, removals, leasings, &c., that it would take long to enumerate.

Manhattan has 12·5 telephones per 100 people, or 295,280 telephones. Bronx, adjoining Manhattan, has 3·6 telephones per 100 people, or 16,310 telephones. The population per telephone in each case is 8 and 27. The Bronx development is lower than that of New Zealand as a whole, which is approximately 1 telephone to 24 people.

The American Telephone and Telegraph Company's engineers during the last two years have devised means by which it has become practicable to load No. 8 or 435-lb.-to-the-mile copper wire. This improvement in the art has enabled circuits to be so arranged that conversations can take place between New York and Denver (about 2,034 miles) that are as good as could be obtained between New York and Chicago (950 miles) before the improvement was effected. This improvement has been brought about by the introduction into the circuits of Pupin coils, which, properly designed and inserted at suitable intervals in the circuits, by their inductance nullify the harmful effect of the distributed capacity of the wires themselves, thus rendering the circuit free from deleterious speech

conditions. It has been found necessary to have good insulation when wires of such low conductivity are being treated in this way. It therefore became necessary to remove all the glass insulators that were formerly used and replace them by specially designed double-petticoated porcelain insulators The insertion of Pupin coils in circuits is called "loading." There are two loaded No. 8 circuits between New York and Chicago; also two between Omaha and Denver. The length Chicago to Omaha is a single pair of No. 8 circuits. A phantom is arranged over the top of the two circuits, New York–Chicago and Omaha–Denver. These phantoms are also loaded. The best circuit for speech over the whole distance is that got by using the phantoms. It would lead to a long discussion to pursue this matter. It should, however, be stated that each of those circuits can have the telegraph superimposed upon each wire, that these telegraph circuits can be terminated at any point desired, and that they can be used right through by suitably arranging repeaters. The whole advantage may be summed up by saying that, while a conversation was proceeding between New York and Denver, nine other conversations could be going on on the same wires between intermediate places, and twenty-eight separate telegraph communications might also be conducted simultaneously. This narration illustrates forcibly the wonderful engineering skill and ability that are at the command of the American Telephone and Telegraph Company, and how their exercise enables largely increased facilities to be afforded with comparatively little cost.

This company has also, from a consideration of the results obtained on aerial and underground circuits by "loading," decided to have complete underground talking circuits from Boston to Washington, a distance of 475 miles. Between New York and Washington the underground conduit was complete, and it was expected to have the other side complete during 1911. Blizzards sometimes so affect aerial lines as to prevent service entirely, and it is to meet such contingencies that these works have been undertaken. The cable will be made up of No. 13 and of No. 10 B. and S. gauge copper pairs. They will be loaded and phantomed. The phantoms will also be loaded. Great care will be necessary in keeping capacity-balances along the route, but it is anticipated that all will result satisfactorily. So satisfied are the engineers of the correctness of their theories that, although actual tests have not been made to confirm them, orders have been placed for 150 miles of cables at a cost, including loading, of about £200,000. The phantomed No. 10 New York to Washington, 235 miles, will have a speech efficiency equivalent to 13 miles of standard cable, the physical No. 10 of 16 miles, the phantom No. 13 of 21½ miles, and the physical No. 13 of 28½ miles. Good commercial speech can be obtained over about 35 miles of standard cable.

Between Boston and Washington, 475 miles, the speech between test-boards over the phantomed No. 10 will be equal to twenty-six miles of standard cable. It is not intended to use these for continuous talk Boston to Washington. Aerial wires will be associated with them over portions of the distance. When, however, stressful conditions of weather mar the aerial circuits the underground is always there to help out in the hour of difficulty.

On several of the long-distance aerial unloaded circuits in the States the American Telephone and Telegraph Company introduce a "repeater relay." This is found to improve speech about 30 per cent. It is, however, not entirely reliable, and is not standard. Sometimes the results are good; at other times frying noises are introduced into the circuit. Arrangements are provided for reversing the terminals and cutting out resistance, and these are often productive of improved conditions.

The insulation of lines in America is generally more easily maintained, and is much higher than can be got in this country even with the best porcelain insulators. Single-shed glass insulators are freely used in the States, and the normal insulation of overhead lines is about 10 megohms per mile.

For leased telegraph circuits the annual rental is usually £4 a mile. Telephone circuits are sometimes leased for £8 a mile. This applies to circuits between cities. Arrangements are often made by which a lessee can obtain a loop telephone circuit before 9 a.m. or after 4 p.m., the wires being used as Morse during those busy hours. Contracts are sometimes made for the lease of telegraph and telephone circuits for an hour or two a day with a minimum of half an hour. The leasing of circuits cannot apply in this country, all telegraph and telephone facilities being in the hands of the Government.

The combining of telegraph and telephone work on the same wires degrades both services somewhat if the circuits are fairly long. The effect on the telegraph for hand speed may be disregarded; that on the telephone is to reduce the distance over which speech can be got, and to introduce slight Morse noises into the receiver. When, however, what has been accomplished over the circuits from New York to Denver, already referred to, is considered, there need be no hesitation in accepting the entire practicability of such arrangements, as there are few circuits with such complicated requirements. The highly efficient transformers now designed are most suitable for that class of work. Although the telegraphs can be worked duplex they are usually worked as simplex, though fitted up as duplex, that being found to be most satisfactory. It is said that a revenue results to telephone companies in America from the leasing of telephone lines for telegraph purposes aggregating about £750,000 per annum.

The care taken to meet fire is noticeable in nearly all exchanges. Water-hose, sand-buckets, asbestos sheeting, and chemicals are usually provided and kept in a convenient place. Switchboards are not yet made of wholly fireproof material. The backs are closed with wooden roller shutters which fold up, and wood is largely used in other parts of the boards. In some cases a waterproofing is placed on the top of the board and arranged so as to be easily spread over the back and front so as to completely cover it and maintain it dry in the event of water having to be used to arrest a fire-outbreak. There are sliding partitions of uralite or of iron, and in some cases bulkhead divisions to limit fire as far as possible. The switchboards, being owned by companies, are usually insured, and insurance companies stipulate certain conditions to be observed.

Subscribers in the States do not advertise their telephone number or print it upon vehicles or bill-heads. They merely indicate by the words "Telephone No." that they are connected to the system. Companies retain the right to change numbers.

In the United States it is generally considered that the public cares more for speed of service than for a lower scale of charges. Acting on this the American Telephone and Telegraph Company and their associated companies provide metallic circuits on a liberal scale, and for long-distance calls effect connections as far as possible within six or seven minutes, with a maximum delay of fifteen minutes. For shorter-distance calls most are effected within two minutes, with a maximum delay of about five minutes. Conversations are usually chargeable for a minimum period of three minutes; around the locality of New York it is five minutes. A "no-delay" basis is used for conversations over short routes—for example, between New York and Philadelphia (90 miles)—and it is proposed to extend it to all toll lines around New York. The A operators, when dealing with calls on a "no-delay" basis, find the toll-line jacks specially coloured, and this reminds them that a ticket has to be made out. The subscriber waits at the telephone for completion of calls on this method.

"Particular" person calls may be made over long-distance lines, and no charge is made unless the particular person required attends.

Some idea of the charges for long-distance calls may be got from the following table:—

From	To	Mileage (radial).	Fee.	New Zealand Fee.
			£ s. d.	£ s. d.
New York ..	Columbus	480	0 16 0	0 5 0
,, ..	Chicago	922	1 0 10	0 9 6
,, ..	Boston	189	0 5 0	0 2 0
,, ..	Rochester	307	0 8 4	0 3 6
,, ..	Philadelphia	83	0 3 0	0 1 0
,, ..	Washington, D.C.	264	0 5 2	0 3 0
,, ..	Pittsburg	316	0 10 0	0 3 6
,, ..	Bridgeport	64	0 1 8	0 1 0
,, ..	Albany	134	0 4 0	0 1 6
,, ..	Poughkeepsie	90	0 2 1	0 1 0

The New Zealand fee is, however, not for radial distances. The American charges are on a basis of 0·6 cent a mile, but other considerations also apply in fixing rates, such as cost of construction and maintenance.

When tickets are passed between the distributing-point and the operator a lamp lights at the despatching-point and remains alight until the ticket is removed. A lamp also lights at the operator's position on the arrival of the ticket. Great care is taken that tickets are properly dry and of a proper thickness. When asked for, information is given to subscribers about charges by an operator to whom the tickets are returned when the call has been completed. Tickets are passed through tubes at a speed of between 20 ft. and 30 ft. a second.

In New York there are about thirty direct-recording operators handling about nine hundred calls in the busy hour. In Chicago there are about eighteen operators handling about the same number of calls. The number of calls per operator varies somewhat in different places according to the method adopted of getting particulars of calls from the subscribers.

When a subscriber puts in a long-distance call his line is kept "engaged" for a time to avoid any other subscriber getting him and his being engaged when the long-distance call has matured. The line is held for, say, five minutes, but if the subscriber wants it it is released to him. He is rung when the call is ready for him to take up. In England they do not keep a subscriber engaged, but on a call maturing, if the calling subscriber has become "busy" or if a called subscriber is "busy," they break in and announce a toll call and ask him if he will take it at once.

Calls at night are charged at the same rate as day calls. It was not so a few years ago, but it was found that reduced rates attracted day calls to the night-time, and the reduction was withdrawn.

As little work of a clerical nature as possible is done in exchanges. The charges are inserted in tickets, and particulars of delays are also obtained. Matters pertaining to accounts are dealt with in the office to which the tickets are daily despatched.

Operators report lines out of order to a monitor, who checks and informs the supervisor, through whom it reaches the wire-chief, and when all is right again the wire-chief advises back. Tickets are used between the wire-chief and the supervisor.

Canvassing is freely done in the States. New York City has about two hundred canvassers. No attempt is made to get subscribers until the plant, switchboard, &c., are available, and these are not installed until the commercial branch has completed its development study and passed it on to the plant engineer. Canvassers are carefully trained in rates and operating methods, and they are better paid than the average run of clerks. They use cards, and record such particulars as are necessary. They revisit twice. If no success attends a third visit the case is abandoned. They are forbidden to oversell, and cases where people take service and then soon give it up are noted against the canvasser. Precaution is taken against reconnecting subscribers who may be indebted to the company.

Advertising is largely used. Outside the exchanges in the large cities it is announced daily what has been the increase of subscribers in the last twenty-four hours. Circulars are freely distributed. There are many uses to which exchanges are put that make them of service to the people apart from their legitimate talking purposes.

In most large exchanges thousands of calls a day come in for the right time, which is given free. The results of baseball matches and of other important events are communicated promptly on inquiry, and special provision is often made to deal with such demands. People are called at early hours in the morning. All this is done free.

Private-branch exchanges are numerous and large in all the principal cities. As a rule there is a telephone in every bedroom of all the leading hotels. Some of these have a dozen operators, six or seven being on duty at the same time. Large department stores, railway-stations, and the like have considerable installations, six hundred to a thousand connections being not unusual.

Telephone-booths are placed in hotel-lobbies, in railway-stations, and in the lobbies of large buildings somewhere adjacent to the elevators. In many cases there are attendants, and the fee, usually 5 or 10 cents, is paid and the person required got before the user enters the booth. In other cases he either pays before calling or after calling and before speaking. Coin-boxes are used in these cases. Throughout American cities very liberal distribution of telephone call-boxes for use by the public exists. They are placed in hotel-lobbies, druggists', tobacconists', and confectioners' shops, and in restaurants. Sometimes the telephone is in a box that the user enters, and which is fairly sound-proof. In many cases the telephone is on the counter or affixed to the wall. The writer has often found these call-boxes, both in the States and in Great Britain, a great convenience.

There are really no fixed principles governing the question of tariffs. Some companies, such as the Independents, generally prefer a flat rate: it has less complication. Companies operating automatic telephones argue that there is no need for measured service, as, girls being dispensed with, the only point to be considered is wear-and-tear of apparatus, and experience has shown that can be neglected. Automatic exchanges can be provided which take care of measured service. It was noticed that there is arising a demand amongst the public for meters at the substation, due to want of confidence in the record kept at the central station under the manipulation of the operator. Telephone engineers do not view any such innovation with satisfaction. The Chicago Commission has laid it down by ordinance that the Bell Company there must place a meter at the subscriber's end, and this may extend. Most Bell companies favour flat rate in all exchanges under 2,000 lines, and measured rates in all larger exchanges. Party lines are provided at flat rates in residential districts. There is a large number of party lines in force in most large exchanges, both Bell and Independent. Arrangements are made to avoid ringing any but the required party. These lines, however, are more liked by the people for the sake of the rate than for any other quality. Conversations can be mostly overheard by the parties, and the line is not always available when it is wanted. Companies find such lines more costly to maintain, and many of them are striving to avoid party lines as far as possible. It is recognized, however, that they get people accustomed to the telephone, and this results often in a better grade of service being taken.

It can safely be said that the consensus of qualified telephone judgment is in favour of measured service as being the most equitable to all classes of users, as small users get service according to their use, and large users are being similarly treated. There are considerations of checking, recording, and accounting that are introduced with measured service that have to be weighed. In the States some commissions when reviewing rates pronounce for flat rates, others for measured rates. Monthly payments seem to assist in securing and holding telephone subscribers. People pay the smaller frequent amount more willingly than they do the larger but less frequent amount.

In all large cities and in most small ones the central-battery manual board is used, except, of course, where automatics have been adopted, and in connection with that system most plants are being converted so as to use a central battery at the exchanges instead of local batteries at the subscribers' stations. New automatic exchanges are always equipped on the central-battery plan.

Magneto-telephone exchanges are practically obsolete. They are to be found in comparatively small places, sometimes in larger places where for one reason and another the displacement of the system by something better has been deferred. Inquirers as to the methods of giving telephone service in this country were never impressed when informed that we were operating so many stations by magneto systems. The experience in the States has shown that it is economical as compared with magneto systems to install the central-battery system in exchanges having not more than two hundred and fifty to three hundred subscribers.

Farmers' Lines.

From time to time a great deal is heard of what is being done for the farmer in the matter of telephone facilities in the United States. There can be no doubt that the number of farmers who have these facilities is large and increasing. The farmer, it will be found, does a great deal for himself. Conversations with persons engaged in the telephone business in the States for many years show that farmers' lines are of various grades according to circumstances and location. It has frequently happened that a knot of farmers would combine and run a line, erect it cheaply, and make an arrangement with some telephone company to give them service at a moderate rate. Faults will, however, occur, and as no one is specially told off to repair them the service soon becomes inefficient. Poles rot and the line falls into decay. Thousands of miles of telephone-lines have had this experience. In other cases farmers combine and form a company, or some person undertakes to form a company to operate in a certain area that will suitably serve a large number of farmers. Magneto switchboards are generally used; poles are cheap; iron wire is employed, but generally a superior-grade service to that just referred to is given according as repairs and maintenance receive attention.

A concrete case will illustrate. A company has two thousand telephones in four towns, population from four hundred to three thousand. There is no manufacturing industry. It is a rural district, and half the telephones are held by farmers, as might be expected. Toll lines run to about twenty-five surrounding cities. The total length of the toll lines is about three hundred miles, so that any one line would be comparatively short. Each farmer may speak free of special rate to one town only. The local rate between towns is 5d. for three minutes, although the three-minute period is not strictly enforced. The farmers' rate is £3 2s. 6d. a year. The company builds the farmer's line, and figures

on one farmer to every half to three-quarters of a mile. It will take the line nine or ten miles. If only fewer farmers can be connected per mile than the number mentioned, or if there are any special circumstances increasing the cost of erection, special arrangements are made by which farmers assist by hauling poles or in some other way. A farmer's line to carry a single iron wire, twenty-five poles to the mile, is said to cost about £10 a mile. Lines are of all prices per mile, according to the number of wires to be carried, which determines the sizes of poles and the closeness of erecting them. Single wires grounded are mostly used. Poles are of cedar, and no pole carries more than two cross-arms. A repeating-coil is placed in the cord circuit. Farmers, it is said, do not want lock-out systems; they like to hear what is going on at the telephone. The company runs single wires on brackets on the poles, and uses glass insulators. In towns of three thousand people the wires are run underground. Two-hundred pair lead cable is the largest used. Fibre ducts in concrete and concrete manholes indicate the construction. The toll charges for talk beyond the area in which the charge has been stated to be 5d. are on the basis of ¼d. per mile for three minutes, and each following minute at one-third of a farthing per mile. Some farmers own their own lines, and the company meets them at the town limits about a mile from the exchange. The charge in such cases is 2s. 1d. a month (practically a switching fee). The company undertakes the tests. The farmer has to maintain his own line and find his own telephones and equipment. The farmers put twenty-five or thirty telephones on an earthed line which may be twelve or thirteen miles long. The farmers' lines erected by the company average eight telephones to a mile. They sometimes have ten. Code ringing is used.

It is quite apparent from this how closely farmers' residences are dotted over the country, the holdings being generally small. Indeed, it is only under these conditions that such development could arise. This feature of numerous farmers in a few square miles was one that always impressed me when passing through rural territory. A question that naturally arises is, what kind of service can that be where so many persons are placed on one circuit with several grounded circuits running on one pole-line? It certainly cannot be very good. The farmers' lines are said to be busy all the time. These lines are not liked by the company, but farmers are accommodated for the sake of the town customers, who insist upon being able to speak to them, and whose business would be lost to the company if they were unable to talk to the farmers.

The rates to subscribers in the towns are—Business connections £5 and residence connections £3 2s. 6d. per annum. Extensions: Business 2s. 1d. a month, residence 1s. a month. The company supplies all material and labour for the extensions.

The area in which this company operates is about twenty-four miles square, and there are sixteen townships. It is this density of distributed population that explains the service that has been referred to.

The company operates cheaply, from 7 to 9 dollars a telephone. The usual investment per telephone in such companies varies from £15 to £20. The operators are paid £4 to £7 a month, and in a few special cases £11. Toll operators get £7 a month. They all work eight hours. Troublemen—*i.e.*, men who go out and remove faults either on the line or at the subscribers' stations—get 10s. 6d. for nine hours. This company does not work under a union rate. Union rates are higher.

Poles last from twelve to fifteen years, but usually larger poles have to displace small ones. Condensers and Columbia dry cells are used in the telephones. This case is fairly typical. In most cases it was found that farmers' lines were not liked by the exchange management. The usual story was that the companies liked to get about two farmers to a mile and would go out seven or eight miles, sometimes as far as fifteen miles to a few subscribers, and take from six to ten on a line—charge 15 to 18 dollars, or £3 2s. 6d. to £3 15s., each farmer. In many cases a metallic circuit of iron wire was given at that rate. 25 ft. cedar poles, 6 in. or 7 in. at the top, range, in the north and middle States, from 8s. 6d. to 12s. 6d. according to locality. Haulage affects the price.

In one exchange it was found that where the farmer's line was about eight or nine miles long the farmers paid half the construction-cost and turned everything over to the company, which charged £3 2s. 6d. each farmer for service yearly. The company maintains the line. They require six telephones on such a line for a start, and will put eight on. In other cases the same company will meet the farmers' lines at a mile from the exchange. The farmers then maintain their own lines. The company charges 10 dollars, or £2 1s. 8d., annually per telephone. All-night service is provided at this exchange.

At another exchange farmers' lines were dealt with somewhat differently. Where they were beyond the usual boundary for ordinary exchange rates the persons requiring service built the line and handed it over to the company, who required six telephones to be on the circuit, and charged for business connections £2 10s. and for residence £1 5s. annually. An allowance of 25 per cent. was made on any business they originated for which charges were made.

The Pacific Telephone and Telegraph Company of San Francisco, operating throughout California, charge an individual as follows:—

Connecting with Exchanges of	Switching-rate per Year.	Payable.	Company furnishes	Subscriber furnishes
	£ s. d.			
300 stations or less ..	0 12 6	Annually in advance to 1st January	Switchboard and circuit to town limits for not less than five subscribers per circuit, central office service, listing in directory, and code ring-card.	Circuit to town limits, complete telephone and battery, substation protection, and maintenance of above.
300 to 500 stations ..	0 15 0			
500 ,, 750 ,, ..	0 17 6			
750 ,, 1,000 ,, ..	1 2 6			
1,000 ,, 2,000 ,, ..	1 10 0			
2,000 ,, 4,000 ,, ..	1 15 0			

The company undertakes the tests. If trouble is on the part owned by the subscriber he pays the company for testing and for removing the trouble if the company has removed it.

In Manitoba the Government owns the telephone system, which is operated by an independent Commission of three experienced telephone-men, and is subject to regulations formed by the Commission. The Commission appoint the employees in the same way as a private corporation would. No free telephones or free messages over toll lines are allowed. Everybody pays full rate for all telephone service. The rural service supplied to the farmers is owned and operated almost entirely by the Government. It is a magneto service, code ringing, ten-party line, averaging about one mile per subscriber. The condition of obtaining one subscriber to every mile of line before building in any locality is enforced. On branch lines where but two circuits are required 20 ft. white-cedar poles obtainable in the country are used, and on the main line poles ranging from 25 ft. to 45 ft. and No. 12 galvanized-iron wire. Western Electric Company's equipment is used at the central and at the subscriber's end. A rural-exchange area usually constitutes a region of about ten miles square.

When it happens that to reach a farmer's residence a line of two poles to half a mile on his farm has to be built he is charged the cost of the poles and of their erection. Outside of that the only charge is 20 dollars, or £4 3s. 4d., per year, payable half-yearly in advance. The rate is considered hardly sufficient, and in the near future it will be increased. The exchange area served is to be enlarged so that a farmer may reach more subscribers. The rates will then run from £4 3s. 4d. for the small up to £7 10s. for the larger distance. The cost of maintenance for rural lines is about £2 per year per subscriber. White-cedar poles last fifteen years and over. The climate is dry, so that No. 12 galvanized-iron wire is expected to last well. Some that has been in service twenty years is still fit for use. Nine thousand farmers are connected to the Government system, and there are about one thousand nine hundred connected to three or four municipal systems, making a total of ten thousand nine hundred farmer subscribers. In all exchanges of over a hundred subscribers a continuous service is given. This can scarcely be called cheap service when it is remembered that there are ten subscribers on ten miles of wire.

In Ontario, Canada, in the small country exchanges the annual rates charged to farmers for telephone service to the nearest exchange are £3 2s. 6d. for each subscriber where the line averages a half-mile per subscriber, and £4 3s. 4d. per subscriber where there is about one subscriber per mile. The number of subscribers on a line rarely exceeds ten, as it is not considered that reasonable service can be given with any more on a line. No. 12 iron wire, glass insulators, and white-cedar poles costing from 3s. 9d. to 6s. 3d. each according to size, are used. The cost of construction is in the neighbourhood of £20 a mile. Metallic circuits are used. Magneto switchboards are in general use. Operators' wages vary from £4 to £7 a month.

Five years ago there were less than two thousand telephones in farmhouses in Ontario, while to-day there are approximately four hundred and sixty systems owned by companies, associations, partnerships, and individuals operating nearly fifty thousand telephones and representing a capital investment of about £830,000. Ninety per cent. of these systems were organized by farmers, who on their own initiative have established the service and furnished most of the necessary capital, not so much to earn dividends as to provide themselves with a telephone service. These systems are of the most varied character in their organization, class of equipment, and cost of service. They range from single grounded iron-wire lines on 16 ft. poles with 3 in. tops to 25 ft. and 30 ft. poles with 7 in. tops carrying 10 ft. cross-arms with metallic circuits. Some of these exchanges are central-energy selective-call systems equal to that provided in cities.

Some systems are operated by individuals and companies with rentals varying from £1 to £3 per annum. Where the rental is under £2 the subscribers usually purchase their own telephones. Some systems are co-operative, each subscriber paying his share of the cost of the plant and an annual assessment of from 4s. to £1 to cover the cost of maintenance and operation. In some cases no assessment is made, but each subscriber maintains his own part of the system. In some cases there are separate party lines of two stations and over. The subscribers build their own pole line to the nearest main line of the Bell Telephone Company, and pay a rental of from £1 13s. to £2 10s. per mile per annum for a wire on the company's line to their office. The subscriber purchases his telephone from the company and pays an annual rental of about £1 for exchange service. In other cases systems are built under the provisions of a Municipal Act by which municipalities furnish the cost of the system to subscribers who are ratepayers, each subscriber repaying his proportion of principal and interest, plus the cost of maintenance and operation, in ten annual instalments. There are about fifteen of these systems, one of which has nearly six hundred telephones. The annual assessment is 11·36 dollars, or £2 7s. 2d., a year, including cost of maintenance and operation. All of these systems are not being operated under conditions that make for durability or permanence. Maintenance is neglected in many cases, and in more numerous instances no provision is made for depreciation. Such systems are liable to decay in the course of time, and as there is no fund for replacement investors in the original plant take the risk of loss of their money.

On some farmers' lines lock-out systems are used, such as those of the Baird Company and Anderson's lock-out. With these it is possible to put as many as fifteen to twenty telephones on a circuit and ring only the subscriber required from the central office. Conversation is also secret. These arrangements, however, bring along some complication, as there is more apparatus at each station to be looked after. They are used to a considerable extent in Manitoba, it is said with satisfactory results. There are other selectors, such as the Gill, the Groce, the Sandwich, the Western Electric: all these find more acceptance for railway circuits, although they can be used for any circuits upon which there are several telephones.

Factories.

The factories of most of the principal manufacturing companies were visited and found to be most interesting. It was noticed that some were not doing very much switchboard work, and that where magneto switchboards were being made they were of small size ranging up to three hundred numbers. It was also observed that several companies were taking up the manufacture of articles not pertaining in any way to telephone work, such as motor-car parts and post-office boxes. A laboratory was associated with the different factories where chemical analysis of materials was carried out on all kinds of materials to ensure that they were free from deleterious substances and in every way suitable for the uses to which they were to be put.

The chemical laboratory of the Western Electric Company, New York, was specially striking in those features. This company were having materials such as galvanized bolts and other line apparatus subjected to weather tests outside, and inside all sorts of weather and external conditions were being as far as possible artificially produced, and materials were being tried under them to determine how they were acted upon. Experiments with materials and made-up apparatus were continually in progress, and were also given a time test to ensure that results would be lasting.

In all factories much attention was being devoted to simplifying the parts of telephones by reducing the number of breakable parts and keeping prominently in view the desirability of maintenance being as little required as possible. Parts of complicated shape were pressed out by successive machine operations from single pieces of metal. The extent to which this is being carried both in America and Great Britain was surprising. Designs also are being produced so that defective parts may be easily and quickly removed and replaced by interchangeable apparatus. This applies not alone to telephones, but to kindred appliances, such as switchboards, relays, &c.

Several factories were visited at Liverpool, Manchester, Beeston, and about London. These compare favourably with corresponding works in the United States, the class of work and the manufactured articles showing a high standard of workmanship and finish. After seeing the various operations and processes to which telephone apparatus generally has to be subjected before the finished article is produced, and the number of persons employed in the production, one realizes that it is only by the application of the best machinery and methods that such suitable appliances as exist are available.

Great Britain.

In Great Britain the telephone is not nearly so extensively used as in the United States. The development has been almost entirely in the hands of the National Telephone Company, and it is only during recent years that the Government has been engaged in telephone work on any extensive scale, and that not in a general way throughout the country, except that toll or trunk traffic has been long controlled by the Government.

The City and Central Exchanges in London, which are in the one building, are good examples of telephone-exchange work. They are of Western Electric Company's manufacture, and have the general features of the switchboards of that company. The Central Exchange has the multiple of the subscribers' lines on the A and B boards, while the City has the multiple on the B boards only. They were designed to accommodate about fourteen thousand subscribers each. The test-room of the City Exchange is fireproof. Lead-covered cables are of 217 and 306 pairs. There is quite a large array of ironwork suitably arranged for supporting cables from the conduits to the main frame. Silk- and cotton-covered lead cable is used for leading to the frame. Jointing is made in the sub-basement; all joints lie horizontally, and are filled with compound under air-pressure. The main frame has the usual heat-coils and lightning-protectors and fuses. The batteries are of the chloride type, about 7,000 ampere hours' capacity. The charging-generators have an output of 1,000 amperes at 30 volts. The exchanges can be worked direct off the generators if necessary. A separate battery is supplied for meters. The ringing-machine gives 75 volts and about 2 amperes at 1,200 revolutions per minute. These carry "Busy back," "Don't answer," and tone tests for faulty lines. The intermediate frame relay-racks, meter-racks, and lamp-resistance racks are all large and strong, and designed for carrying about twenty thousand lines, and arrangements are made at one end of the intermediate frame to provide for cross-connecting between the frames of the two exchanges. Condensers and fuse-boards are suitably disposed. Everything is on a very large scale, and runways are large, strong, and well supported.

The switchboard of the City Exchange is of fireproof construction. The framework is of iron, and the woodwork of the front of the board is lined with metal, and also the doors at the back of the board. The key-shelves have the usual seventeen pairs of cords, meter-keys, order-wire keys, and supervisory lamps. The B boards have twenty-seven single cords and machine-ringing. The operating is done in the manner usual where large numbers of subscribers have to be handled and where there is a lot of trunking to other exchanges. About a hundred answering-jacks were allotted to each position, but at the intermediate frame this can be reduced if desired. The boards are nine-panel. Outgoing junctions are multipled every six panels.

The City Exchange has about 130 employees, with 7,414 stations and 4,762 extensions. The Central Exchange has about 420 employees, with 24,151 stations and 13,862 extensions. There are six information-girls on each floor, one monitor to about every nine girls.

The New Avenue Exchange in Cree Church Street, for which the equipment has been supplied and erected by the Peel Connor Company, is the newest exchange of the British Post Office, and is a fine piece of work. The cables are 600 pairs, 10 lb. copper. These are divided below the floor of the main frame into three 200-pair silk-and-cotton-covered cable, and each 200-pair comes up in an iron pipe let through the floor opposite the vertical on the main frame to be served. There are sixty-eight of these 200-pair cables, or 13,600 pairs. Cables are all very neatly treated and led off to the different racks. Glass fuses are used on the main frame. Wires are not fanned in the usual way, but are led to the tabs of the vertical springs through wooden blocks bored and placed vertically. A new feature

is that the voltage of the battery, which is 40, is maintained constant during all hours by having a booster in series with it, so that as the voltage of the battery falls the booster voltage can be varied to keep 40 volts steady.

The B board is on the first floor. It has fifty-eight positions. Each position has thirty cords, and is fitted for thirty-six. The multiple is on this board only, and not on the A board. The sections are nine-panel, 6 ft. 4½ in. long. Ringing is automatic on the B operator plugging in. No subscriber can be rung, however, unless the A operator has a cord up to the junction that has been assigned. The B operator cannot listen-in. She can handle five hundred to six hundred calls an hour. The calling-rate on this exchange is expected to be twenty-two calls per day per subscriber, and it is the busiest in London. This is to take the place of the old Avenue Exchange of magneto type in the locality. Fireproof bulkheads, shelves, and covers are provided inside the switchboard. Lighting is all done from the ceiling by Osram lamps, but arrangements are provided on the board for lighting by reflectors if required. This applies to the A room also. There are three or four monitors' and supervisors' desks in the B room.

The A switchboard is on the second floor, and has 123 positions. Each position has the usual equipment on the key-shelf. The sections have eight panels. Each operator has 130 lines to attend to. There is capacity for 200 lines. There are ancillary jacks in sets numbered 1, 2, 3. Operators attend to the calls on their direct lines first, and then, as far as they can, take calls on jacks in the sets marked 1 next, and so on. This is said to assist team-working. It is also in operation in the United States, but it is doubtful if there is advantage gained to warrant the cost. Monitors' lamps are fitted every few sections, and a monitor or a learner can plug in. At the end of the A board there is an arrangement for cutting off particular sections from an order-wire circuit. This enables an order-wire circuit fault oftentimes to be easily located, and does not hang up the entire circuit. When the plugging-up lines are used a tone is put on the faulty line, so that operators know that it is out of order when they test. According to the nature of the fault, this plugging also lights or does not light a special lamp. The attendant, if the lamp lights, throws a key which puts it out. On removal of the fault the lamp lights, and it is at once known that the fault has been removed.

There are three trunk positions fitted with thirty cords and listening and ringing keys. Three hundred girls will be employed in this exchange. The kitchen is 30 ft. by 15 ft.; dining-room, 42 ft. by 30 ft. There are wooden lockers placed back to back, with good space between rows of lockers. A rest-room is provided. A fire-alarm system with numerous points from which alarms can be sent in is also installed. This exchange has been erected in six months, and it was stated that it was the first time that the Post Office had got an exchange completed up to time. The Post Office engineers expressed themselves as in every way satisfied with the work that had been done.

Some time was spent at the Gerrard Exchange, one of the largest in London, which was erected by the Western Electric Company for the National Telephone Company, and taken over by the Post Office at the time of the transfer. Everything here was of first-class workmanship, and the general lay-out very good. This exchange had more the appearance of and seemed to be well in line with the class of work that exists in the States. What surprises one in all these large exchanges is the orderly and methodical way in which large masses of cables are taken care of and extended in suitable iron runways overhead from one point to another. Neatness and cleanliness prevailed. Great precaution against fire was taken, even to providing outside the switch-room a telephone in a convenient place so that alarms might be sent by direct circuit to the fire-station. There are about 9,000 lines and 23,000 stations on this exchange, with 106 working A positions and 41 B positions. The lines allotted per A position are about eighty-four. The calls per line and per station per day are 14·4 and 5·7 respectively. In the busy hour the average number of calls answered by A operators is 164, and the work on these is equivalent to about two hundred and thirty-nine straight-line calls. The percentage of outgoing junction calls is 73. Each outgoing and incoming junction carries approximately 100 calls per day. B operators in the busy hour effect about three hundred and ninety connections. Their calculated load under the conditions existing is 366. The number of A operators is 147, of B operators 53, supervisors 18, monitors 11, managerial, record-testing, and other clerks 14, and private-branch exchange operators 63, a total of 302. The relief staff and extra operators number 29. It is found in all exchanges that girls work best when they are working without slackness or strain.

Gerrard is a common-battery exchange, and the figures given may be taken as approximately applying to several other large exchanges in the City of London. Some of the exchanges that were being operated by the National Company as magneto are being changed over by the Post Office to common-battery as speedily as possible. Avenue, already referred to, is one, and Westminster another. At Willesden an exchange was seen fitted with Peel-Connor apparatus, and at Finchley and Barnet the installations were of Western Electric type. These were common-battery installations, and were all suburban, with a few hundred subscribers, and were well equipped and finished. The buildings were substantial and roomy. There was ample space for further extension.

Girls in the London Post Office telephone service work forty-eight hours a week, but not necessarily eight hours a day, and may have to perform duty on about one Sunday out of four. They do not work after 10 p.m. They are taken between the ages of sixteen and nineteen. Learners are paid 7s. a week. On filling a vacancy they get 11s. the first year and 14s. the second if employed within the London postal area, and 10s. for the first year and 12s. for the second if employed at exchanges outside that area. Increases thereafter vary from 2s. to 1s. 6d. a week each year up to 28s. Second supervisors are paid from £80 to £100; first supervisors from £100 to £145; and chief supervisors, from £145 to £190 yearly. Men's wages are from £1 5s. to £1 10s. a week. About 5 per cent. to 10 per cent. of the girls are generally absent through sickness. Annual leave is granted on the scale of a fortnight per annum up to two years' service, and thereafter three weeks annually.

The trunk exchange was visited, and was found to be very interesting. The room is large, being about 45 ft. wide by 120 ft. long, and extending further in a right-angled turn. The equipment consists of 118 working positions, 4 spare positions, 448 trunk lines, 547 junction lines, and 149 record lines. Each section consists of three panels. The centre panel contains rows of twenty three-point jacks. These junction lines are worked with call wires, and part go to common battery and part to magneto exchanges. There are two other rows of five jacks, and lamps which go to A transfer sections and to "local subscribers' sections." Some local subscribers make special arrangements to have telephones at their premises for trunk-working only. The other panels are called "trunk panels." Each is fitted high up on the panel with five name-plates and five "outward" concentration jacks, so as to pass the trunk lines to another part of the board at night. Just beneath these are ten "inward" concentration jacks. The two lower rows of jacks on the panel correspond to these, and when the top sets are plugged the bottom are not, and *vice versa*. In the centre of each panel there are rows of twenty jacks for the signalling-junctions. Each has a button associated with it, which upon being depressed lights a red lamp common to all if that junction is engaged. The junctions are multipled over several sections. Lower in the trunk panel are strips of twenty jacks and lamps for the B transfers.

For transfer work there are two switching positions. Any operator getting a demand from one toll line for another plugs into an A transfer. This calls the transfer operator, who gets the order and plugs into a B transfer-jack in the verticals before her. This lights a lamp at her position and another at the position required. On the call being taken up both lamps go out, and when the conversation is completed they light again, upon which the transfer switching-operator takes down the cord. This action passes a lamp signal to the A transfer originating-operator, who also takes down the cord.

There are forty-eight record positions. Subscribers' demands reach these positions through record switching-operators. These operators have plugs before them, the tip and ring of which lead to the record operator's lamp and key. On any demand they merely take up a plug, insert it in a jack, and at once the subscriber can give particulars to the record operator, who prepares a ticket and despatches it by air-valve to the distributing-centre, where it is examined and then sent by air carrier to the proper trunk position. The record operator on receiving a call pulls her speaking-key and the lamp darkens. On restoring that key a signal is given for disconnection at the switching section. When a conversation is completed the ticket is retained at the section for some time, so that inquiries concerning the call may be facilitated if any are made.

A 3½-horse-power motor is installed for the ticket-distribution. Vacuum is used to the distributing centre, and pressure thence to the trunk sections.

There are eight telegraph call-wire circuits. This class of circuit is going out of use; fewer are employed now than formerly. There are two telephone call-wires, and about sixty other ordinary order-wire circuits. The originated calls are about eight thousand to ten thousand a day.

The French outgoing calls are 180; incoming, 230. Belgian, about sixty each way. The speech on the two foreign sections was listened to, and was found to be good. It was better, however, on the loaded than on the unloaded circuits. Several of the circuits to the provinces were listened on and found to be quiet. Operators are not given more than five circuits to attend to.

There is a large blackboard at one end of the record-table on which is written the delay that is occurring on circuits during the different hours of the day, so that operators may be able to advise the public as demands are made. This delay is often twenty to thirty minutes, and runs up to forty-five minutes and over at times. There is not the liberal supply of trunk wires here that there is in America.

The writer has frequently heard a business man speaking from London to another at Manchester, and found there was considerable difficulty in their understanding each other.

The following gives an idea of the class of circuit provided, expressed in terms of standard cable: There are ten circuits to Manchester, each equivalent to about fifteen miles of standard cable, so talking should be easy. The circuits to Liverpool are better, there being sixteen, and four under erection. These represent twelve miles and a half to thirteen miles and a half of standard cable. London has four circuits to Glasgow as good as those to Manchester.

All trunk lines are twisted. Some discussion arose in America about the relative merits of twisting and crossing wires. They prefer the crossing methods in the States. There is, however, much to be said for twisting, which is also done on the Continent.

It should be mentioned that in this trunk exchange there is a system of informing subscribers speaking on the trunk wires when the three-minutes period has elapsed. These time-checks were also seen in operation at Manchester and at Liverpool trunk exchanges. They are well spoken of. A master clock works a relay which controls several electro-magnets. A shaft on which are mounted ten wheels is moved by the electro-magnet, and revolves in twenty-four minutes. There is a friction-clutch which, when current is applied, causes a part to be set in motion, and which at the end of three minutes has moved so far as to close a contact, which lights the line-lamp. The operator then advises the speakers of the time. At the beginning of the conversation the operator pulls out a little button near the line-lamp, which closes a circuit through a coil in the clutch. Pushing back the button breaks the circuit, releases the clutch, and allows the movable piece to drop to normal.

Liverpool and Manchester trunk exchanges have almost as many positions as London. Liverpool has eighty-four. Tickets, made out here by record operators who sit at a table in the centre of the room, are placed on a travelling band and conveyed thereby to a distributing-position at the end of the record-table, and delivered thence by hand to the trunk sections. There are about four hundred and twenty trunk circuits. Between Manchester and Liverpool there are sixty-eight trunks, many of them underground and loaded. The distance is about forty miles. There is an 80-pair underground cable made up of 40 lb. copper loaded,

Manchester has 433 trunks. They are working 114 sections, and have 132 in the room. There are 220 persons on duty at the same time, and about 250 on the staff. As showing the number of circuits necessary to some centres, it may be stated that there are twenty-one to Ashton and thirty-two to Oldham.

These trunk switchboards are all of British Insulated and Helsby manufacture. The methods of working are practically the same in all. The number of calls that can be handled on a circuit in the busy hour is about ten, and an operator does well when she handles thirty calls in an hour at her position. Circuits used to be actually paid for only during thirty minutes of an hour, but arranging for the next call by telegraph raised that to forty-two minutes, and the telephone call-wire enables forty-five minutes paid time per hour to be attained.

Continent of Europe.

On the Continent, except the automatic development, there was little of interest seen as compared with the United States and Britain. In Berlin the trunk positions were slightly detached from each other, and girls were attending to not more than three circuits—many to two, and some even to one.

At Munich the exchanges seen were old mangeto type, with many additions on the key-shelf and anywhere space could be found for adding jacks and apparatus to meet requirements not originally provided for on the board. An improvement would be welcomed. The movement is towards automatics, which are also favoured by the engineers at Berlin.

At Munich, in a large room near the public entrance to the telegraph-office, were sixteen booths for the public. In the same room there were two girls who allotted the booths and collected the money. They had jacks by which they could supervise the time at each booth. Each person paid the fee before entering, but if time was exceeded the girl made a demand when the person speaking was finished.

Munich has a flat rate—£7 10s. up to three miles air-line for both business and residence. The measured rate is £4 10s., and 5 pfennig, or about ½d., each talk. Every 100 metres are charged 3s. beyond the three miles. Speech to several exchanges not far outside the city is free of any toll rate. Generally up to fifteen miles the charge is 2½d. for five minutes, fifteen to thirty miles 3d., thirty to sixty-two miles 6d., sixty-two to 310 miles 1s. To Vienna and Paris the charge is 3s., to Berlin 1s., and to Hamburg 1s. 6d.

In Paris there is little of interest. The exchange equipment was still that which had been hurriedly put up in the temporary structure that was erected in the street adjoining the exchange building in which the fire occurred about three years ago. In the basement into which the tunnels carrying the lead cables lead was a 25,000-line distributing-frame of the Western Electric Company's type. Lead cables, each containing about 240 pairs, were occupying every available inch of wall and other space. There were large iron heads for 112 pairs, in which joints were made, and the interior kept airtight by the cover being screwed tight down on to rubber gaskets, and these heads were placed wherever room could be found. Great activity was going on in the tunnels preparing for the change over to the new exchange that was soon to be installed in the renovated building. Messrs. L. M. Ericcson and Co. are the contractors for the new switchboards, which were expected to be ready about May. There were 874 female operators and 75 supervisors employed. Men work at night. The law does not permit of women working after 9 p.m. The operators work eight hours daily. The men's pay ranges from 1,500 to 2,400 francs, or £62 10s. to £100, per annum; average, £75. Women receive from 2s. 4d. to 3s. 3d. a day. Sundays and holidays are paid for as overtime at the rate of 25 per cent. above ordinary pay.

Reference has been made to loading-coils. These are used in many places where the underground cable is long and the wire small, to increase the talking properties of the circuits. They are introduced really to enable light wire to be used, so as to reduce the cost of junctions. In cables they are placed about one mile to one mile and a quarter apart. They are freely used in the United States on aerial wires, and have lately been applied to large conductors with good results, although the same ratio of increase of distance does not result as with the smaller wires. In Germany and Austria loading of overhead wires is largely availed of. Messrs. Siemens and Halske, of Berlin, and other firms have developed coils and metal cases for them with lightning-arresters and methods of mounting that minimize troubles which under certain conditions have been found to result from the use overhead of loading-coils.

ORDINARY TELEGRAPHY.

The Western Union Company's telegraph operating-rooms in Chicago consist of two large rooms about 50 ft. wide and 200 ft. long, one above another. There are about a thousand employees, and six hundred persons are on duty at one time in both rooms. The lines come in in lead cables underground, are taken to a main distributing-frame similar to telephone frames, and are led thence to the test-board. Associated with the test-board are numerous banks of lamps, which are used for cutting resistances into the circuits as required to keep the current of the desired strength.

Dynamos are run in the power-room giving positive and negative current of voltages 7, 24, 50, 75, 110, 220, 280, 340. These are led to the operating-room, and plugging arrangements are provided by which any voltage may be picked up. Constant current is very largely used upon the shorter circuits, of which they have about two hundred instruments for the city work alone.

The rooms are very crowded. There are over a thousand lines to different places. Some are lines of the American Telephone and Telegraph Company, and are composited. The test-boards take up a lot of room, as they are not at all compact. On a platform running along the test-board the instrument leads terminate in cords and wedges, which are supported on the

platform just as cords in a telephone-switchboard are. A little above the platform there are heavy brass curved pieces with strong springs. By inserting an instrument-wedge under one of these springs any instrument can be connected to any line. Some lines have two springs, so that two sets of instruments can be placed in series in the circuit if desired. Way-lines are provided from one part of the test-board to another to facilitate connections.

There is a wire-chief to every fifty lines on the test-board. This man sits before his allotted portion of the test-board, and with a set of instruments provided near him can cut in on any line and attend to trouble. One board that was carrying the local lines had equipment for about three hundred lines, where only one wire-chief was attending to all, as these circuits are less liable to trouble than cross-country lines.

The administration aims not to exceed ten minutes' delay, and 80 per cent. of the work is done with five minutes' delay. It telephones large numbers of messages, up to twelve thousand a day, so as to obviate delay, and as far as possible desires not to deliver the telegram if it has been accepted by telephone. There are over twenty girls engaged on that work in a special room.

In telegraphing to the Atlantic coast cities there is usually one repeater in circuit; to the Pacific coast two or three repeaters are employed. San Francisco works to New York through six repeaters, but the speed is not higher than twenty words a minute.

On one duplex circuit from Montana to Chicago, two thousand miles long, it was noticed the signals were slower and more deliberate than on the shorter circuits. The sender at Montana was using a machine key. Many of the men working on the fastest circuits use these keys. They seemed to be making no effort, and the men receiving and using typewriters also seemed to find no effort in keeping up with the fastest sending. The operators seldom break. The use of typewriters may be said to be universal.

Adjusting of instruments did not seem to be often necessary, which was accounted for, no doubt, by the general dry and hot weather prevailing at that time.

Noting the speed at which the operators work on the principal circuits, the conclusion arrived at was that in New Zealand we have numbers of operators who are quite capable of doing equal work. The average length of messages was stated to be about thirty words, including the preamble. This figure was also given in other cities. Operators send and receive fifty-five to seventy messages an hour on the fastest wires, and this applies to a few of the medium-distance quad. circuits. On long quad. circuits the speed reduces considerably. The B side is often shaky. Numbers of quad. circuits are ruined by high-power circuits running in their neighbourhood. One man looking after quad. circuits has a device by which he has rendered useful many lines that were useless, and he hopes still to improve it. It is kept secret, and no information could be obtained about it. On quadruplex tables the A sender and receiver occupy one side, the B sender and receiver the other side. Each receiver had a key as well as the sender, so that he may when breaking do his own sending. When he has to break he marks "bk," and the sender hears his sending on the pole-changer or transmitter broken, and stops at once. There are no acknowledgments of messages. These messages are passed away for distribution as soon as finished, to avoid delays.

Every circuit has the messages for it numbered consecutively. The senders allot the number as they send, and both senders and receivers are watching that they miss none. The receiver merely draws a line through a number on a sheet of paper as he receives the message so numbered, so that if the sender allots a number out of sequence or duplicates a number it is noticed. Where there are two or more wires to the same town the numbers are prefixed by letters, thus: A1, A2, B1, B2, and so on. A receiver acknowledges the first message, and then it is assumed he is at his post. They often go for half an hour or an hour without breaking. If any fault comes on a line, then careful watch is kept to see no messages are dropped.

Repeaters do not seem to need much attention. In the case of three or four sets of repeaters in circuit it is found that when signals are being received well and clearly at the received end they are cloggy and nearly unreadable on the first set of repeaters. Special men are told off at the different offices to deal with repeaters.

It is said that from 275 to 300 messages an hour each way pass between Chicago and New York. About 120,000 messages a day are handled in Chicago, and about the same number in New York.

Operators come on at 8 a.m. and work until 5 p.m., and on some circuits until 5.30 p.m. Half an hour is given for luncheon. They are working as fast as the circuit will permit all the time. When a man is not fit for a circuit he is not kept at it, and either has to take a slower one or he is not wanted. Operators working the fastest circuits get 100 dollars, or £20 16s. 8d., a month. Women are paid the same as men for the same work. There were no women at the fast circuits. Other operators are paid 70 to 75 dollars, or £14 11s. 8d. to £15 12s. 6d., a month. There were not many female operators. There were many women in the machine-room perforating and writing up Wheatstone tape. The pay is about 30 dollars, or £6 5s., a month for that class of work. Wages are paid twice a month, and it was said that many men were absent after pay-day. There are no bonuses paid after a certain number of messages has been sent. Such a system did exist, but it has ceased for some years.

Wheatstone working is done, but not to a great extent. This system had not been long adopted, and it was said instruments had not yet been brought up to speed, but it is intended to persevere. Repeaters are used when the circuits are longer than about 450 miles. One circuit was seen working to New York at about a hundred words a minute, and another at about a hundred and fifty words a minute. The tape is punched on Barclay perforators. A girl can prepare four hundred messages a day if she is expert. The usual number perforated is about three hundred and fifty daily, or about forty-five an hour. Baskets are not used. The perforated tape is wound into a figure 8 and pinned to the messages, which are in batches of two, three, four, or five, but not so many as to give rise to delay. Sometimes there is only one message on

a slip. Tapes are destroyed at the end of the day. The received tape is mostly given to women to typewrite. They do not get through more than twenty to twenty-eight messages an hour. The methods of doing this work seemed to require improvement. The transmitters and receivers were motor-driven.

A modified Morse alphabet is used so as to meet the Wheatstone requirements. It was said that the Wheatstone working gave promise of being more suitable than the Barclay. All instruments were fitted on the tables here. It was noticed at San Francisco that the bulk of the instruments were mounted together on special stands, with shelves in tiers, so as to be under the control of special men. The operator's table had only a sounder and key. This method was found to be very satisfactory. The same arrangement as at San Francisco was also in New York so far as a large number of the circuits was concerned. Many circuits, however, had all the instruments on the tables

There is quite a number of Barclay instruments working to different places, such as to Denver, Kansas City, St. Paul, St. Louis, Cincinnati, Louisville, Washington, Cleveland, Detroit, New York, Pittsburg, and Boston. The officer in charge of this section, who was working at a faulty set, informed me that they go wrong in all sorts of ways, and that it is the unexpected that is always happening. He said he liked them, but added, with a twinkle, that he was earning his living by them. It is found that by having a few spare sets on to which to change when anything goes wrong with the sets in use good results are obtained. The mechanicians are engaged upon them a great deal, so that the upkeep is considerable. On the other hand, it is claimed that skilled labour is dispensed with. Two girls at each end can attend to the transmitter and receiver, and two girls at each end can keep the transmitter supplied with tape. These girls are paid about 30 dollars, or £6 5s., a month, and it is not considered that the extra upkeep of the instruments amounts nearly to what is saved by working in this way. There is no third person in this office checking received tape at the Barclay, as was noticed at another office, where, however, there were only two circuits. One message only is perforated at a time, and it must be accurate. The speed is not high, and the circuit must be good. The instruments will duplex, and when the distances are long repeaters are used. I timed the messages frequently, and found the rate of transmission to range from thirty-four to forty-two words a minute. At 4 p.m. one day at the circuit from Detroit the received number was 541 and the forwarded 635. As this was eight hours, the average was sixty-seven and seventy-nine an hour over the circuit, but it was only an average of thirty-seven messages an hour a pair, as there were four persons at each end. On occasional days more is done, but generally if they dispose of five hundred to six hundred messages a day each way it is considered to be satisfactory. This agrees with what was seen elsewhere of the work done by this instrument.

On a balcony on the ninth floor there are three or four distributing-positions towards which messages come to be sent off in other directions. There is an arrangement of carrying-wires, a rope driven by a motor, and spring clips. The clips pick up messages and drop them also at predetermined points. There are pulleys, and the clips pass over these, alter direction, and turn through the ceiling to the operating-room on the next floor above. In one case messages are brought to a chute passing through the floor to a room below. The clip is opened by a projection just as it reaches the chute, and the message falling in is drawn to the floor below by the suction of a small fan at the bottom. These carriers, however, do not deliver to the different tables, but only to the ends of a section comprising two or three tables. Tables are not small as in our offices: they are about 4 ft. wide and 20 ft. to 24 ft. long. Several instruments are placed on them without any partitions between them. Operators at the different tables sit back to back with not much space between the backs of the chairs, and passages are so narrow it is not easy for two persons to pass. At each delivery section distributors (boys and girls) remove the arriving messages and place them at their respective instruments on the tables, and despatch those received at the instruments, so that they may quickly reach their proper circuit or be so placed that they will reach the despatch or the telephone room. At each table there are eight or nine persons seated on each side of it.

In other cases there are boys in the middle of the room attending to carriers that are propelled to the ends of the room, where there are also boys who remove the messages, replace others, and shoot the carrier to the middle again. Transfer between the two operating-rooms is effected by these rope carriers going up and down at three different places. The present system is old—it has been in operation since 1893—and is to be replaced. Two or three motors are used: one is 5½ horse-power, another ½ horse-power. The carrier is a metal spring fitted with fibre which runs between two wires, the carrier being taken forward by the motor-driven rope. The speed of the carrier is about 6 ft. or 8 ft. a second. There is also a system of vacuum pneumatic tubes for use to different rooms in the building and to some places outside.

The Postal Telegraph Company, of Chicago, have their operating-rooms on two floors about 65 ft. by 250 ft. There are about six hundred people working at one time. Cord carriers are used here for picking up and transferring messages. The carriers pass messages between the floors. Twenty-seven seconds are occupied by a carrier in going the full length of the room. Distributors dispose of the work from the distributing-points to the instruments and *vice versa*. The management aims at having only a five-minutes delay on telegraph work. There are pneumatic tubes for sending messages all over the building, and into the adjacent Board of Trade building. These operating-rooms provide fair space for operators and for those whose duties require them to move about.

The lead-covered rubber cables are brought up a well to the main frame, thence to a half amp. fuse and carbon lightning-arrester, thence to an intermediate frame where they can be cross-connected, and then on to the test-board. The test-board is of the same type as that already referred to, and men cut-in their instruments and test in the same manner. They have a large number of repeaters, the shelves for which extend about two-thirds across the room, and are

arranged in tiers. Lamps are not used as resistances. These are made of wire, enamelled so as to readily dissipate heat.

Quadruplexes are worked fast. The B side is not too good, except on comparatively short lines. Gerritt Smith's relay and condenser arrangement is used for correcting the kick of the B relay. As dynamos are used up to about 385 volts, which may be tapped at points in the sets of dynamos to get intermediate voltages, strong currents are employed. Heavy currents are used on all American telegraph circuits. The Stephen Feild system of connections is employed generally for quads. Machine keys are used by the men even on the fastest circuits, but their use has to be tempered with discretion, as if the dots are too fast the signals at the distant end arrive light.

Figures or doubtful words are not repeated in telegrams. The theory, which is a correct one, is that there should not be any such. An operator should break when there is any uncertainty.

Two hundred and eighty messages are considered a day's work. For any over that number the operator receives ½d. each, and it is not unusual for men to earn, besides their wages, as much as from 4s. to 14s. a day. Good operators are paid from £18 10s. to £22 a month. They work nine hours a day. Others receive from £17 to as low as £13, according to capability. Women are paid the same as men for equal work. Two women are working circuits, for which they were getting £17 10s. a month. Women are mostly engaged in distributing, however. At night 170 messages are considered a day's work, and operators are paid 1d. for every message over that. An operator may go off duty when he has sent his 280 messages in the daytime, and sometimes, although not often, that is done by noon.

Many of their circuits are much affected by power lines. Near Hammond, in North Michigan, they have twenty-two wires ruined by high power, and they are fighting the power-user in the Courts. The effect of this high-power induction was seen on several circuits. All would be normal and going smoothly, when suddenly the repeater would chatter just as if a telephone generator were applied to the circuit.

Duplex was working to Montana, approaching two thousand miles away, with, of course, repeaters. The signals were good, but fast work cannot be done on circuits of this kind. A repeater in a duplex circuit, New York to San Francisco, was listened to and was working well, but at only about eighteen words a minute.

Wheatstone automatic working to New York was introduced a few weeks prior to my visit. The perforating was being done by hand. The circuit was 200 lb. copper, and there were no repeaters. The distance is about 950 miles. At the receiving end the signals are perforated on tape at about a hundred words a minute, although duplex has been worked at one hundred and fifty words a minute. The perforation at the receiving end is effected in the following way: To the tongue of the receiving relay 385 volts are applied from the dynamo, the other pole of the dynamo being earthed. The marking and spacing contacts of the relay are connected to separate electro-magnets of 150 ohms each, the other terminal of the electro-magnets being joined to a condenser, which is earthed. These electro-magnets are so set up that they control their armatures in such a manner that pins on them suitably perforate the tape. This tape is then passed through an apparatus that has two brushes, which make contact with the roller whenever a brush meets an opening in the tape, and by this means a sounder is operated. The operators typewrite from the sounders at any suitable speed. The tape can be divided amongst several operators if desired. The speed of perforation at present does not exceed a hundred words, as the electro-magnets fail if more is attempted. This is worked mainly at night, and it is intended to develop it. The transmitters are not of the magneto type—they are motor-driven.

This company was operating the Rowland system for a couple of years, but, although when in good order it did good work, it was so complicated and uncertain that its use was abandoned.

The Wright and the Morkrum systems of type-printing telegraph are now being used. The Wright printing-machine works from impulses controlled from the keyboard direct. The keyboard is like that of a typewriter, and has fifty keys. The depression of a key selects and transmits the impulses for the required character. A small motor rotates a cam shaft, which moves once round, when a key is depressed. There are four positive and four negative signals, which are combined by the keys in such a way that the impulses suitable for each character pass to line. The positive impulses turn the type-wheels and the negative impulses lift it. A slow-acting magnet comes into operation on the lengthening of a final signal, by which the type-wheel is turned back a little. The result of all this is that the type-wheel can send out the fifty characters. At the receiving end there is a relay with a double tongue. One armature lifts the wheel and the other turns it. On the reception of a signal the type-wheel moves to the position corresponding to the impulses, and the tongue of a polarized relay in the local circut of the first relay rests at the completion of a signal on one or the other stop long enough to complete a local circuit so that a latch may be released to allow the cam shaft to revolve once. The cam shaft has several cams which bring about different movements necessary to print the letter and have all in readiness for the next impulses. The batteries used are 130 volts, earthed at the centre to work a relay which repeats the positive and negative impulses from 385-volt dynamos. At the sending end the message being transmitted is printed on a long sheet of paper so that the operator can see all, and also to provide a record. The message is recorded at the receiving end on the forms which are fed in by the attendant. The line can be duplexed and these instruments used. The speed is not high, being about thirty words a minute.

On three consecutive days from 8 a.m. to 5.30 p.m. two women dealt with 450, 451, and 239 forwarded messages, and 277, 272, and 320 received messages. This comes to thirty-eight messages an hour a pair, as there are two engaged at the distant end also. One way one pair was working at fifty messages an hour. There was not enough work to fill the wires. At New York it was found that from one thousand to one thousand one hundred messages a day could be handled

in nine hours by the Wright system. If the operator makes a mistake in a message it has to be sent a second time.

Mr. Wright had almost completed another machine which was to dispense with motors and to be worked by electro-magnets. The instrument may be said to be still in a state of development, and there is not a large number in use.

The Morkrum apparatus also enables about eleven hundred to twelve hundred telegrams to be dealt with on a circuit in a day of nine hours. There is no tape used. The inventors have been nine years engaged in perfecting the machine. It has worked from Chicago to New York through repeaters quite satisfactorily. Some of the railways were using it to a limited extent. The current required is about 30 milliamperes. The instrument is stated to be hardy. Much care has been taken to provide for the speedy removal of faults by a process of elimination. Parts are made easily removable and interchangeable, and are subdivided a good deal. When trouble arises parts are removed one by one and another substituted. A special alphabet like that of the Baudot is used, but as the combinations are effected by the keys of the keyboard the typist does not need to know the alphabet. The keys combine positive and negative impulses in a certain manner according to the key struck. Any key just lightly touched is pulled down by magnetism, as a circuit is set up. Any key depressed and kept so prevents any other key from being depressed, as all are locked. The depression of a key arranges certain levers, so that they determine the order of the impulses to line by their action upon a bank of seven transmitting relays. The impulses pass through two polar relays in series. One polar relay works the home recording-apparatus as a check on what is sent. The line current picked up at the tongue of the other in response to the impulses goes to the split of a polar duplex. They balance by galvanometer, which is unusual in the States. The recording relays at each sending end are in a local circuit. There are earth line, two local-battery terminals for 110 volts, and the main-line battery, of which the voltage can be varied, and either dynamos or chemical batteries may be used. The incoming signals work a polar relay which works banks of receiving relays. The impulses from these move discs in which are holes. There are four of these discs side by side. Any movement which makes holes so fit in all four discs as to be exactly opposite each other, allows pins worked by springs to drop into the holes, and this in turn mechanically rotates the circular typeholder so that the proper letter is opposite the paper and the blow is struck. In front of the typeholder is a small ink-pad on a spring. As the typeholder comes forward it rubs on the pad, which then passes on to the top of the typeholder. As the typeholder moves forward to impress the letter on the form a small projection on its mechanism breaks the circuit, so that everything is unlocked ready for the next letter. The paper is stationary. The typeholder moves along. The polar relay is wound to 140 ohms, half on each coil. Large currents are used, because of induction from high-power circuits in places. Key and sounder can be switched over to, if necessary.

These instruments had been in use only about eight or nine months. The proprietors do not sell, but rent them for about £12 10s. a month. The Wright Company does likewise. The Postal Telegraph Company is going to use the Morkrum machine fairly extensively. Comparatively low-priced labour will be used—girls at £6 to £9 a month, instead of operators at £17 to £20. As about sixty-five messages an hour per pair of operators can be handled, this is considered to be good business.

The Morkrum Company is beginning to manufacture. The factory was visited, and it was seen that a first-class array of tools is ready.

The pole-lines of the companies carry thirty to forty wires. The conductors are mostly copper, about 170 lb. to 200 lb. to the mile. It is stated that they pick up a good deal of induction from their own circuits, owing to the length of the lines and the strong currents used. Polar relays are wound to 300 ohms and B relays to 150; sounders to 150, and some to 250.

The general finish of instruments used for telegraph purposes in the States was rougher than that seen in Britain and on the Continent.

On railway wires where there is a large number of stations, there are means by which any station can be called without disturbing the others. A bell is rung. There is mechanism at each office which will respond only to a particular combination of signals sent from the calling office. This mechanism is somewhat involved, and would not fill any need that we have.

Loop lines pass away to various offices all over the large cities. In these offices leased lines are worked through repeaters at the main office. A shutter is arranged at the main office, and if the loop office wants to obtain the attention of the main office a key is depressed, which causes the current to be so increased that the shutter opens and the testing officer cuts-in on the line. There is some variation in methods for doing this at different places.

These leased lines are a source of considerable revenue to the companies. The general rate is £4 a mile. Some lines are leased for only twelve hours. One circuit was mentioned as being leased for £3,200 for day use and £2,200 for night use per annum. When newspaper offices are extended to, operators are sent to these offices. The only charge is the rental, except when loop wires only are leased, then the operator is provided and charge is made at the message rates. The *Times* newspaper telegraph-office, New York, was visited at night, but no special features were observable. The officer in charge asked for men to be sent to him from the central office according as he saw they were needed, and he ordered them back as the work slackened. Most Press-work is done at the office of the newspapers, so that the central-office staffs are much reduced at night.

In the Western Union Telegraph Office, New York, there are four test-boards. The references already made to cables from underground, battery leads of different voltages, use of lamps as resistances, double sets of springs so as to cut into circuit more than one set of instruments by inserting wedges, way-lines for connecting from one test-board to another, all apply. There are red lamps on these boards which glow when a leased wire or an extended wire is out of order.

Most extended loops are merely local-circuit loops with the line apparatus, such as relays, &c., on shelves in the central office. There is a large number of these shelves, with men disposed amongst them attending to balances and any other matters demanding attention. The bulk of the quad. and duplex instruments being operated in the main office are also upon shelves, the keys and sounders only being extended to the tables. In some cases all of the instruments are on the operating-tables. During a thunderstorm which came on suddenly one day it was most interesting to note the way the men attending at the shelves had to move about from one place to another to attend to the varying conditions arising from minute to minute.

Galvanometers are not used. Balance is by working signals. In quite a few cases a milliamperemeter was in circuit on a quadruplex. Quadruplex is not used through more than one repeater placed, say, four hundred miles distant. 20 m/a and 60 m/a are obtained from dynamos. Most quadruplexes are used as direct lines to cities up to four hundred miles or a little more. In bad weather it is quite usual to have to close the B side and work the A side with the full battery. Glass insulators are used. The best insulators are not obtained; they have to be imported, and become too costly, as there is a duty of 40 per cent. A duplex circuit to San Francisco working through six repeaters was listened to. The signals were good. The sender of them was using a machine key. The speed was about twenty words a minute.

The total staff was about eleven hundred, and three hundred and fifty to four hundred operators were on duty at one time. About 120,000 messages a day, including transmits, are handled in New York main office. Wires are leased at about £4 a mile, and special arrangements can be made for leasing during certain hours. Male operators work nine hours a day; female operators eight hours since a recent law to that effect was passed. Men's pay ranges from £10 to £19 a month. Women are paid £1 10s. to £1 17s. a week as distributors, and when employed as perforators or attending to keyboard-machine circuits the rate is from £2 to £2 17s. 6d. a week. Some are paid by the hour, some monthly. Men do not work quite so many hours at night as during the day. Annual leave is not granted. Yetman typewriters were not seen in use anywhere. The vibroplex and that type of key is much used by operators for sending, and gives good results if used with judgment. Fifty messages an hour are common on certain classes of circuits. This company has no system of bonuses for messages sent in excess of a certain fixed minimum. There was such a system at one time, but it was abandoned.

There is a large number of circuits worked simplex to places inside and outside the city. In some cases lamps are arranged to light on a call coming in on these circuits. The lamps are elevated and placed in a row. By this means an operator per circuit is avoided, as it is found that a large number of circuits can be attended to by a few operators. A wandering cord from the instruments is plugged in to pick up any circuit it is desired to attend to. The idea was good, but the method of giving effect to it seemed rather primitive. There were about twenty-five to thirty of these circuits on one long table.

On an elevated platform there were about sixty men and girls attending to carriers and the distribution of messages. A large number of carriers converge to this point, and most messages come here. There is also a pneumatic-tube system radiating, by which messages are despatched to and received from many parts of the building. Messages as they arrive are sorted and put into the proper carrier, which takes them to their destination. There are two travelling-belts also running. These are driven by motors on the platform, and there are spare motors to carry on with if one should break down. Messages placed on one belt are passed downstairs to the operating-room below; those placed on the other belt are carried to the other end of the platform, to be redistributed by carriers which deliver at definite positions, where male and female distributors take up the messages and convey them to their proper circuit. Some messages can be distributed without using the carrier system: that is done where found to be most suitable. No attempt is made to distribute to each instrument direct by carrier.

On the floor below there is a second central position for carriers, and pneumatic distribution, where there are about fifteen persons employed. The Barclay instruments are in this room. There are twenty-one in use, and four spare ones are kept. Two mechanics are continually employed keeping these in order and repairing the perforators, of which there are about sixty. Girls can perforate forty to fifty messages an hour, but they vary in skill, like operators. The perforator operator numbers each message in sequence, and only one message is put on one tape. The operator at the instrument times the message as it goes through the machine. There is one girl for sending and one for receiving. The girl receiving checks the words and watches for anything that may need correction. In some cases where the work is not heavy a girl perforates and feeds direct into the transmitter. Message after message is then passed along on one tape. If the receiver or transmitter goes out of order, transfer is made to another receiver or transmitter. The part working all right is not transferred with the defective part. Transmitting is then going on at one place and receiving on the same circuit at another. Tape is destroyed after two or three hours. At the beginning of each tape a few dots are sent. There must be no errors in perforated tape. If one occurs the tape must be either destroyed or the error cut out. Faults occur in the instruments that are sometimes difficult to find.

Work is done with these instruments to Chicago through one set of repeaters at Buffalo, 460 miles distant. They work direct to Boston, Philadelphia, Buffalo, Washington, distances of 250, 90, 460, 270 miles. Nine hundred messages on a circuit both ways from 8 a.m. to 6 p.m. are not unusual. Several messages were timed passing through the transmitter, and the speed was found to range from thirty-four to forty words a minute, and was about the same on all circuits. One feature of the Barclay was that, while not fast, it was going uninterruptedly, and no time was lost, so that it was possible to put through sixty to seventy messages an hour each way. As it takes four persons at each end—that is, two to prepare tape and two to attend the instruments—the work done amounts to only about thirty-five messages for each two persons. This is about

the same as a duplex, the only difference being in the rate of pay for Barclay operators as compared with Morse operators.

The dynamos give 3, 4, and 7 kilowatts. The voltages are 7, 24, 40, 70, 140, 200, 260, and 330. One machine, compound-wound, excites itself and the others. One set of five machines is negative, one positive; a third set can be made positive or negative as wanted. Dynamos for 7, 24, and 40 volts are separate. The 7-volt dynamos will give 800 to 1,000 amperes. The amperage of the others is much smaller according to voltage.

There is a large switchboard for controlling the power for the elevators and lighting for the large building. They have their own furnaces and generate their own electricity, but they can connect to the city mains if their own supply fails.

The pneumatic-tube service extends for some miles to different offices and all through the building. Ten minutes' delay only is permitted from the counter to the distant station. There is a tube from the counter delivering upstairs. From the time of receipt of a message to the time of its reaching the despatch not more than five minutes should elapse. Only single copies of messages are taken. Water copies on flimsy are taken by the despatch branch, sorted, and sent to the controller. Messages for the despatch are dropped from above, from the central platform already referred to, through a chute, and an exhaust fan at the bottom draws them down. After the water copies are taken the messages are passed on an endless running belt to the addressing-men. The messenger's book is prepared, the messages entered, and the charges named. The books are passed to another man, who hands them to the boys, and notes who the boys are and the time they start. Another man takes the books on the boys' return, checks their time, the returned messages, and the money.

Special messengers are sent for by the public to take messages to the office. This service is free. Messengers are also sent for for errands, for which a fee is charged. A special person is detailed to supervise this service. There is a large number of tape instruments on which the calls come in. At the counter the clerk has a sheet in which are filled the number, destination, and value of each message as it is taken. Received messages are telephoned to any person who has a telephone. A large number of persons are engaged telephoning received messages and receiving others for transmission. The company takes the risk of error, also of payment. When the telegram is received from a telephone lessee he is held responsible for the charges. They have had no difficulty so far in collecting charges for telegrams. A special place is being set apart in the operating-room in which to attend to the telephoning of messages, for which no fee is charged.

This company, which is practically owned by the American Telegraph and Telephone Company, has recently employed a telegraph engineer from Britain to put its service on a level with the standard of telegraphy in that country. It is recognized in America that, while that country is in the forefront in telephone matters, telegraphy as practised in Britain is superior to the American methods.

Telegraph-offices were seen in Philadelphia and Washington, but there was no departure from what has been referred to. Carrier systems for the distribution of telegrams were not in use in those places. That work was done by girls and boys. The telegraph companies employ about thirty-five thousand males and five thousand females. The Postal Company's system is mostly confined to the larger towns. The Western Union ramifies more, and since it has been combined with the American Telephone and Telegraph Company there is a movement to reach much smaller places than have been hitherto served. Telegraphists move about a good deal, as there is always demand for skilled men.

On the important circuits for which a bonus is paid by the Postal Company for all telegrams transmitted in a day beyond a certain number, the following are some figures that have been attained: Telegrams sent, 686, 772, 557, 668, 598, 565, 547, 555, 640, 609, 772; received, 523, 564, 539, 554, 559, 567, 644, 592, 675, 770, 692. These were handled from 8 a.m. to 5.30 p.m. They run from sixty to eighty an hour throughout the day. These speeds are not general, but they are not unusual on certain good duplex circuits. Operators usually send and receive alternately for a couple of hours. At night they work seven hours and a half. The average speed is said to be about twenty words a minute.

In the Western Union Company the average pay is about 65 dollars, or £13-odd, for males, and about £10 for females, a month. The rate of pay is based on ability. The Postal Company grades operators into three classes, and the pay for these ranges from about £8 10s. to £20 a month.

A system of telegraphy was seen operating in a workshop through artificial resistance at a rate of six hundred words a minute, and it was stated a thousand words had been reached. The transmitter it not unlike a Wheatstone, and tape has to be prepared. The received signals are marked in characters very closely resembling roman characters, but there were a few defects in the form of three or four letters that had to be overcome.

There was also seen in New York the "Dean Rapid Telegraph system." This is also worked by tape, which is placed so as to feed into a typewriter resembling the Hammond. The typist operates the typewriter, which causes the tape to be marked with specially devised embossings to represent each letter or character. The tape also receives an impression of what has been typed as a check on the work. It is then run through a transmitter and is received page-printed at speeds up to 250 words a minute. The received characters are of a special alphabet and can be quickly learned. All messages have to be typewritten at the received end before being sent out to the public. The system was in active business operation between Kansas City and St. Louis for two or three years, but seems to have been discontinued.

The Telepost was seen in Chicago and New York. The paper tape is perforated from a keyboard or by the ordinary tapper method. There is also a device consisting of two flat keys

and a space-bar by which the paper can be perforated. The depression of the keys closes a circuit when slightly moved, and magnetism does the rest. This is not unlike the method of perforating by air-pressure. There is another arrangement by which tape is perforated by the working of a Morse key in conjunction with a pole-changer, relay, and punches. The tape can be perforated at fifty or sixty words a minute. Centre holes are not cut. The forward feeding of the tape is effected by friction roller. Above the perforated tape as it passes over the roller of the transmitter are two metal brushes — one connected to the positive the other to the negative of the battery. The signals are sent, when these make contact with the roller through the perforations. From one thousand to one thousand five hundred words a minute can be transmitted. The static capacity of the circuit is necessary to the successful working of this system. The demonstration given to me was through a local circuit with resistance of 1,000 ohms representing the line. Condenser to represent the charge and discharge of the line was introduced, but no result was got when the condenser was cut out. Short lines which have not enough surface to provide the necessary capacity of themselves have condenser supplied to make up the deficiency. The signals are received on chemically prepared tape. The transmitting tape can be run through the transmitter with the finishing end first. This causes the received tape to be in the right way to begin writing up when the message is through the transmitter. Tape can be perforated at the received end and at any number of intermediate stations, or it can be received on perforated tape at one or more offices, and on chemically prepared tape at other offices. The re-perforated tape can be run through a machine and written up from a sounder at typewriter speed if desired. This perforation of the tape at the received end was seen being done on a local circuit at seventy words a minute. A most interesting feature is that the starting of the transmitter causes the tape at the receiving end to start also, and when the transmitting tape has run out a signal is automatically applied to the line. This works a relay at the receiving end, which stops the receiver by the action of a local battery.

It was said that the company expected to have a line operating from Chicago to New York quite soon, and that they were actively engaged in connection with the system in Boston.

It was in England, however, that the telegraph methods impressed one most, and, although large telegraph-offices had been seen in the States, a walk through the operating-rooms of the London Telegraph-office disclosed that there telegraphy was being conducted on a scale that was unrivalled and by methods that invited investigation.

All the circuits of the Central Telegraph-office are brought into the test-room in the basement in twenty-nine lead-covered paper cables of about three hundred wires each. The gauge of the wires varies from 40 lb. to 150 lb. a mile. They are taken to distribution-heads, where they are connected to silk-and-cotton covered cables which are led to testing-jacks and protecting-devices fitted on the main frame. The main frame will take 10,000 wires, and has now 3,150 circuits, many of them looped metallic circuits requiring two wires. Silk-and-cotton lead-covered cables extend to the instrument-rooms, and are enclosed in iron troughing. It is a feature of all the wiring that it is enclosed in iron right up to the instrument-table, and that all wires are lead-covered. There is a desiccating plant consisting of a 2-horse-power motor-driven pump, and seven cylinders for drying out the paper-insulated cables should the insulation become impaired by moisture. About one thousand secondary cells of capacities varying from 30 to 750 ampere-hours are used, and are so grouped as to give voltages of 10, 20, 24, 40, 50, 80, 100, 120, and 150. By these means current is obtained for short and long lines, local circuits, pneumatic-tube signalling-wires, bell circuits, small electric motors, and the intercommunication switch. Primary cells are not entirely dispensed with, as there are over four thousand in use, principally dry cells, used for telegraph metallic loops, as it has not been found practicable to work these from the earthed secondary cells. There are fifty-five pneumatic tubes, having a total length of about forty-nine miles and extending to various metropolitan offices. These are $2\frac{1}{4}$ in. and 3 in. in diameter, some worked by vacuum and others by pressure. The longest tube measures 4,100 yards, and the speed attained by the carrier is thirty miles an hour. Besides these street tubes there is a large system consisting of seventy $2\frac{1}{4}$ in. and 3 in. tubes used for house service in and between the several buildings. A signalling-wire and apparatus is provided for each tube, thus enabling the despatch of a carrier to be signalled and its receipt acknowledged. Several carriers can be in the street tubes at the same time following each other at definite intervals of time.

A message telegram concentrator, which is really a telephone switchboard, provides for connecting to it about eighty telephone circuits from various post-offices and exchanges throughout the city. These are used for telephoning telegrams to the Central Telegraph-office. Forty sets of telephones are employed at the Central, which are plugged through, as they become disengaged, to the calling circuits.

The Foreign Gallery contains circuits to France, Germany, Austria, Italy, Belgium, and Holland, and a portion of it is allotted to work for some of the English towns in the Midlands. There are about 224 circuits in this gallery. Over sixty of them are worked with Hughes instruments, and about the same number by sounder, duplex and simplex, single and double current being used. Eight Baudot quadruplex and twenty-six ordinary quadruplex are also made use of. The Baudot sets work to Paris and to Berlin, in the latter case through repeaters at each end of the cable, with satisfactory results. Telewriters or telautographs are employed to a limited extent. Whatever is produced at the sending end, whether it be writing or sketches, is similarly reproduced at the receiving end.

The Provincial Gallery provides for over three hundred circuits working to the principal towns in the British Islands, and is the busiest of all the galleries. There are about a hundred Wheatstone sets, duplex and simplex, forty ordinary quadruplex, sixty double-current sounder duplex, some forked repeaters, duplex repeaters, and Hughes duplex. A Murray multiplex is working to Manchester as a double duplex. A Baudot quadruple duplex works to Birmingham. The Creed type-printing apparatus is used in connection with four sets of Wheatstone duplex to

Edinburgh and Newcastle. The news division is in this gallery. A portion is set apart for the preparation of perforated slip for the Wheatstone system. A good deal of tape was seen being prepared by the manual method of using the three tapper keys. Tape is also prepared by the double pneumatic punchers. This is an arrangement by which two ordinary perforators are placed one above another in a suitable wooden receptacle. A supply of compressed air at a pressure of about two atmospheres is provided. The operator works three keys corresponding to dot, space, and dash. These keys release air to operate tappers which force down the perforator keys, and the movement of these causes the paper tape to be perforated just as in ordinary hand punching. The tapes are placed in revolving trays, and are so disposed that one tape, or any other number up to eight, may be perforated simultaneously. When not more than four tapes are required, the compressed air may be turned off either one of the perforators. Gell and Kotyra keyboard perforators are also operated in this room. Here also is to be seen the chronofer, an electro-magnet device, the movements of which are controlled by a weight-driven clock, which is adjusted to send currents through the electro-magnets at 10 a.m. and 1 p.m. daily. All the lines that have to be supplied with time from Greenwich come to this mechanism. Nominally the lines are connected through to their instruments. A short time before the hours for transmission of time a current passes from the clock, and in one movement the lines are disconnected from their instruments and connected to a system of relays from which a permanent current is put on the lines to all the offices. The actual time-signal from Greenwich is received on a relay which reverses the current. This reversal operates the various galvanometers, time-balls, and other arrangements throughout the country.

The test-board for this gallery has accommodation for 1,800 circuits. All line wires are connected to this board, and wires are taken thence to small test-tablets placed at the end of each table, and finally to the respective instruments. This facilitates testing, as inside and outside faults can be quickly distinguished. Most tables are large—their width is about 4 ft., while the length varies according to the position they occupy—but the instruments for several circuits are placed on one table. Partitions between instrument sets are not used. Sounders are placed in resonators.

In the Metropolitan Gallery the intercommunication switchboard is installed. This has accommodation for about forty operators, who are all women. About nine hundred circuits from various parts of the city and suburbs come to this board. The switchboard resembles that of a telephone exchange. Each position has several pairs of cords and plugs, each pair having a key so as to cut in the operator's telegraph set on any pair. All the lines are multipled at every position, and when any line is plugged into an engaged lamp lights at every position. Any out-station wanting London operates the key, which causes a flashing on the calling-lamp. The operator plugs in, and with the other plug connects away to a disengaged working set without speaking. When finished working, each depresses an indicator key, which gives the "Disconnect" signal to the operator at the switchboard. If an out-station requires another out-station, the operator on seeing the calling-lamp light plugs in and pulls over her key. This action changes an indicator at the out-station, so that he signals on his Morse the number required. The operator, with the other cord, completes the connection. When finished, the out-station presses the indicator, which gives the "Disconnect" signal to the operator. The electrical apparatus required to effect these various indications is not involved. By these means it is found unnecessary to place any battery at the out-stations, where polarized sounders are used. Large secondary batteries of 40 and 36 volts are provided at the central office. The possibility of connecting such a large number of out-stations together in the manner mentioned saves delay and obviates the need of providing instruments, floor-space, and staff for transmitting purposes. It is found that the work to and from these stations dealt with at the central office can be handled on about 270 sets of instruments. This gallery also accommodates about fifty double-plate sounders and fifteen quadruplex sets. Cord carriers are in use on the various floors. There are several distributing-tables, whence the telegrams are conveyed by hand to the different circuits. Five master clocks control eighty-three dials, which are 12 in., 24 in., and 36 in. in diameter. The mechanism of the dials is operated by impulses generated at half-minute intervals.

On the roof there is a workshop measuring 120 ft. by 17 ft. Accommodation is provided for about forty mechanics and boys, who are employed in the maintenance and repair of the apparatus in the galleries. Besides these about a dozen mechanics, who are experts in Hughes and Baudot apparatus, are located in a workshop adjoining. A number of linemen and construction hands are constantly engaged in removing faults and running new circuits. Altogether an engineering staff of fully a hundred persons is permanently employed.

The telegraph-offices at Manchester, Liverpool, and Dublin were visited. The work in these was mostly being done by the methods with which we are familiar in this country—viz., simplex, single- and double-current duplex, quadruplex, and Wheatstone. Dublin had a couple of Gell machines for the perforation of Wheatstone tape. They said they could work these perforating-machines at forty to fifty words a minute. They did not claim to be as skilled in their use as the staffs in the cities in England that were using them. The operators could perforate by the usual manual-tapper method at twenty to twenty-five words a minute. News messages received over the cable from London by Wheatstone are forked away by repeaters to both north and south. There were fifteen positions at which girls with telephones were seated for receiving telegrams from and despatching them to different parts of the city.

Manchester was working the new Murray multiplex apparatus, which had been installed on an underground circuit between that city and London. It was a double duplex, giving four channels, two sending and two receiving. This had been in operation only a short time. The man in charge of the set stated it was doing very well. It was said to be capable of dealing with a hundred messages per hour per channel. Owing to the staff's inexperience the result was a good deal below that number. There were nine men engaged, four at London and five at Man-

chester. The work being done was 1,400 as a maximum in seven hours and a half. On one side there were 40 forwarded, 50 received, and on the other 56 forwarded, 66 received, between noon and 1 p.m.—total 212, or an average of 53 per channel. The daily totals do not properly represent the work that can be done, as during some hours they are slack. During the hour 1 to 2 p.m. 159 was the total; during 2 to 3 p.m. only 69 were dealt with on all the channels. Different day's totals for seven hours and a half were 1,066, 1,108, 1,058, 1,141, 1,237, 1,240, 1,376.

The inventor looks upon the London–Manchester installation of his multiplex system as purely experimental, and would not recommend, at present, its adoption for our conditions, as he expects to be able to still further improve it as a result of this experimental working. By the end of this year he hoped to have it in all essential respects in standard form, so that he might make special tools for manufacturing it more cheaply than can be done now.

The Murray multiplex is like the Baudot, in that a distributor is employed to give each operator use of the line. The speed of the multiplex is forty words a minute, as compared with thirty words a minute on the Baudot. Each operator has a typewriter-keyboard, and perforates tape by depression of the keys. The tape goes through the transmitter at the forty-words rate, but the operator may work at sixty words or more a minute, and can thus time his messages. There is no skill required of the operator beyond being able to typewrite. Provision is made to prevent errors appearing at the receiving end. The operator can correct an error so that it does not appear on the page-printed sheet. The tape is fed into the transmitter by mechanism driven by a magnet which is operated at regular intervals. There is a "cadence" contact on the distributor which effects this. The tape is then taken up on an automatic tape-winder. The operator can stop and start the tape when he pleases, as there is a lever provided for that purpose which is locked until the right instant. He can also by perforating a special signal arrange that a perforator at the receiving end may be brought into operation to prepare a message for transmission on some other circuit there, a record being also printed at the receiving end. On the completion of the message the perforator is automatically cut off, only to be cut in again at any time the special signal is sent. The distributor-brushes are controlled by vibrating-reeds, and thereby kept in unison with each other. Before it was decided to prepare apparatus for the present experiment a six-months' trial of a more limited portion of the apparatus was made between Birmingham and London. Two girls were operating the keyboards. After about a month's experience they could punch forty to forty-five messages an hour, and after about three months they were able to perforate 100 messages an hour. The work passed over the circuit reached 100 messages an hour on several occasions, and 126 were done in one hour. It is desirable to keep in touch with the experiment now being made, as this apparatus gives promise of good results, and its first cost is not too great.

Manchester had also a couple of Creed instruments. These receive a message in the form of perforated tape at a speed ranging from 90 to 130 words a minute. This tape is then available either to be passed through a Wheatstone transmitter to reach other offices, or to be passed through a Creed printer, when the message will be recorded in roman characters on tape at a rate of about 100 to 115 words a minute. This tape is gummed to forms as it is printed, and the message is ready for delivery. On a circuit two Creed instruments and a Wheatstone receiver were connected in series, and all three were made to work simultaneously with satisfactory results at about 100 words a minute. The Creed is found to be invaluable here on frequent occasions at night. News messages often arrive for transmission to another office or offices at a late hour. Before the Creed was used the practice was to receive them by Wheatstone, write them up, then perforate them for retransmission. The Creed obviates all that labour and delay.

A great deal of Wheatstone automatic work is done in this office, the Gell perforator being used to some extent to prepare the tape.

There was nothing special at Liverpool calling for comment. At night this office is put through to five different points on the Continent through repeaters, and they use Hughes instruments.

The Murray automatic was not working in the London Telegraph-office during my stay, but it was seen working at the Murray workshops in the experimental room of the British Post Office, and in the telegraph-office, Berlin, where there were three sets in operation. This apparatus has been in use for some time, and on long lines, for which it is best suited, has given good results. The tape is the same as in Murray's multiplex system, and is prepared on similar typewriter perforators. It is, however, passed through the transmitter at a speed ranging from 100 to 180 words a minute. At the receiving end the signals are perforated on tape, and are an exact copy of the perforations at the sending end. The received tape is then passed through an automatic typewriter, by which the message is recorded in roman type in page form at a speed of 150 to 200 words a minute. The machine is strongly built to endure the strain of the high speed. The demonstration that was given at the Murray workshops was at a speed of 150 words a minute, and the record, of which a sample was taken, is clear and free from blemish. The apparatus will work duplex, and where repeaters are necessary the usual Wheatstone repeater is used. The claims for this system are that where a circuit is long—say, seven hundred to a thousand miles, and even more than this—and where there is a volume of business of from a thousand to two thousand messages a day, the work will be better and more quickly transmitted by this apparatus than by any other, including Wheatstone.

This system is in use between St. Petersburg and Omsk, a distance of 2,224 miles. The line is of iron, about 800 lb. a mile, and is divided by repeaters into four sections. The duplex speed with the Murray automatic is approximately sixty words a minute each way, and when Wheatstone working was employed the speed was from thirty to thirty-five words a minute each way. Where lines are only of moderate length, while it is desirable to increase the output of

each one, more attention is directed towards reducing the cost at the offices for which there are other kinds of apparatus somewhat more suitable.

It was said that the instruments working in the Berlin Telegraph-office gave good results, but that the cost of maintenance was high, the principal trouble occurring in the automatic type-printer. This was a recognized difficulty wherever the instrument was used until the inventor devised a specially strong typewriter, which it is claimed is proving to be quite satisfactory.

In the Central Telegraph-office, London, the Creed instrument was seen working upon two circuits to Newcastle. They have them working also upon the Edinburgh circuit. At the transmitting end of a circuit upon which these instruments are used the usual Wheatstone automatic apparatus and methods are employed. The messages are perforated either by the manual methods or by the use of the typewriter keyboard appliances, such as the Gell, that have been devised for that purpose. At the receiving end the signals, which can be received in the ordinary way on tape if desired, are made to work the Creed apparatus, which produces in perforated tape an exact copy of the perforated tape that was used at the despatching end of the circuit. The Creed machine is purely mechanical. The mechanism provides for actuating punches under the control of the line signals, for moving the receiving tape forward at a uniform speed, and for momentarily holding the tape during the act of punching and then promptly releasing it. Compressed air is employed for working the tappers that perforate the tape. The air-pressure is about 30 lb. to the square inch. The receiving relay has no local circuit. Its tongue is fitted with a light extension which opens and closes air-valves so that a piston is made to move from side to side. This movement operates rocking-levers, which control other similar valves. These admit more power to a piston, which also moves to and fro. This piston has levers attached, associated with which are steel strikers which cause the punches to perforate the tape. A small motor of about one-sixteenth of a horse-power is used to drive the paper-feed wheel. The current required for the relay is about 15 to 20 milliamperes. Tape has been perforated by this machine at 200 words a minute, but 100 to 120 words is nearer the actual working-rate. In some cases this re-perforated tape is passed away to another position for retransmission of the message to another station. This has been referred to as being done at Manchester. More usually the tape is passed through a Creed printer, so that a second tape which is running becomes marked with the message in roman characters. This printing is done at about 100 words a minute, although a higher speed of 135 words is claimed for it. The tape is gummed to message forms as it issues from the machine. An operator can gum these messages at rates varying, according to skill, from 150 to 200 messages an hour. A message is usually considered as consisting, on the average, of twenty words, including address and signature. The action of the printer is involved. The result, however, is that the perforated tape is fed forward by a star wheel rotated as required by the movement of a rack. There are selecting-needles which penetrate the perforations and control space-levers, so that any one of ten slide-valve plates can be made to occupy a certain position relatively to the others. The slide-valve plates are of steel, are thin, and fit closely to each other. They are each bored with numerous openings. Compressed air enters at the bottom of these plates, and according to the movement of any plate an opening is provided to a particular cylinder in which is a piston which operates a type-bar lever. Each combination of the plates admits air to a different cylinder, so that the printing-apparatus is under the control of the perforated tape.

For long submarine cable purposes Creed has arranged what is termed a "telegraph translator." It is a mechanical instrument. As is well known, long cables are worked by equal positive and negative impulses, so that when tape is used the positive currents are arranged for on one side of the feed-holes and the negative currents on the other. The received Wheatstone tape, being useless for cable purposes, is passed through the translator, and another tape is produced perforated so as to be suitable for passing to the cable the impulses in proper order. This second perforation can be done at the same speed as the first.

Cable work has to be performed with marked freedom from error. One cable company in London that was visited informed me that the Wheatstone transmitter, through which tape was being passed, was working into a circuit in which were two repeaters to the Atlantic cable-station in Ireland, where a Creed instrument was receiving the messages as perforated tape, and translating that into tape suitable for the cable. The messages reached the American end, therefore, without the delay that is unavoidable when they have to be written up and either perforated by hand or sent into the cable by hand at the originating end. This was said to give entirely satisfactory results, and the company had three circuits to Ireland so equipped.

Another cable company operating across the North Sea, and serving Russia, Denmark, Sweden, and Norway, was using Creed apparatus in its London office and at Newcastle, which was the terminus of the cable and of the land line in England. This company had two sets, one or the other being always working, and frequently both. A third set was kept as a standby in case of trouble arising. The circuits were being worked duplex at about eighty to ninety words a minute. One circuit, of 300 miles, was of iron overhead; the other, of 357 miles, 100 lb. copper underground. One man was attending to the receiver and gumming the messages, but when the flow of work is constant it is necessary to have two, as the speed mentioned implies about two hundred messages an hour. Three or four men were hand-perforating for each set. They can perforate up to eighty messages an hour. The messages average fifteen words.

The Creed was also being used at Newcastle, but not for translating purposes. The messages are tape-printed there as in London. This company had been using the Wheatstone receiver, and upon introducing the Creed apparatus found that they could reduce their staff practically by half. Perforating for the first transmission was done by hand. Men were seen perforating at fully twenty-five words a minute, and occasionally at a faster rate. They seemed to be well able to maintain the speed, and it was especially noticed how little time was lost. Typewriter key-

boards for perforating were not used by these companies. It was stated that one mechanic could attend to three sets of Creed perforators and printers and the apparatus generally used in the office where these were. One company had two mechanics, one of whom was in attendance at night.

A number of cable companies are using the system, and when the Creed works were visited it was seen that there was in progress the construction of a large number of receivers and printers for one of them.

Figures got from the British Post Office showing the results over their circuits are as follows:—

Time.	10 to 11 a.m.	11 to 12	12 to 1 p.m.	1 to 2 p.m.	2 to 3 p.m.	3 to 4 p.m.	4 to 5 p.m.	Total for Day.	Hours.
Forwarded	149	219	206	93	..	..	..	667	4
Received	190	217	161	139	..	..	..	707	
Total each hour ..	339	436	367	232	..	..	..	1,374	
Forwarded	137	191	192	134	100	138	119	1,011	7
Received	193	211	196	137	102	150	124	1,113	
Total each hour ..	330	402	388	271	202	288	243	2,124	

These figures show that the apparatus can handle over two hundred messages an hour each way when there is the work to do. The average each way for the eleven hours was 159 messages an hour. It is, however, proper to ascertain what the instrument can do by the work dealt with in the busy hour. That work was 218 messages an hour each way. It was said that at the London end alone there were sixteen men employed during the busy hour.

With keyboard perforators each operator typing at forty words a minute for forty minutes should prepare seventy messages on tape per hour. Three such operators at each end would feed the machine, allowing one for the transmitter and two for receiving and gumming. There is thus a total of six persons at each end, which gives thirty-six messages a person an hour. Working Morse, two persons are required to deal with a message—viz., a sender and a receiver—so that this result fully doubles the efficiency of each pair of operators, and doubles the carrying-capacity of the line, always assuming there is sufficient traffic to keep it filled during the business hours of the day. The work done is equivalent to seventy-two messages per hour for each pair of men engaged.

These instruments are costly, the price for a duplex set at one end being £2,120. This includes two spare keyboard perforators and one spare transmitter, receiver, and printer. The price, excluding spare apparatus, is £1,140.

Mechanicians' attendance and repairs have not been referred to, as they would be required for any kind of machine telegraph, such as Murray, Baudot, and Siemens.

The Gell keyboard perforator is supplied with these instruments.

The foregoing figures are based on everything working ideally, which seldom is the case. Probably eight or nine pairs of operators would represent more nearly the general working requirements. This would make the average per pair of operators between fifty and fifty-five messages per hour. Information has been received that the company has now devised a means by which the apparatus can be worked by electro-magnets, thereby dispensing with the use of compressed air.

The working of what is styled "systematic Wheatstone" in the British Post Office has features demanding notice. Keyboard perforators of the Gell and Kotyra type have been developed to that stage at which they can be considered as giving satisfactory results. The speed of the Kotyra is about forty-five words a minute, that of the Gell eighty or ninety words a minute. These machines are, like all machinery, liable to wear and occasional breakdown, but the wear is not so great nor are the breakdowns so frequent or serious as to make their maintenance heavy or to cause them not to be used. The Gell perforator has been improved so that the inventor has it practically in its final form, and is standardizing it. The British Post Office has about one hundred in use, at least thirty of which are in the Central Telegraph-office, London. They were also seen in the Dublin and Manchester telegraph-offices. In a newspaper office the writer has seen fifty-eight words in one minute and 123 words in two minutes perforated on one of the machines. Where they are in the hands of skilled typists they are generally considered as giving more than twice the result obtained from the manual perforating method, from which about twenty-five words a minute are obtained. One hundred and 127 messages have been perforated in an hour, but these speeds are not common, the average being more in the neighbourhood of sixty to seventy an hour. The perforating of this number of messages per hour is not unduly severe, as most typists can type at forty words a minute with ease. This rate for forty minutes in an hour will produce 1,600 words, which at twenty words a message gives eighty messages. Under strict Post Office test at the *Daily News* office, London, an operator perforated tape which was fed direct into the transmitter at London and received at Manchester; 3,620 five-letter words were sent during one hour, the rate being sixty words a minute.

The Gell perforator is also in use on the German-Atlantic cables. The slip, which is perforated suitably for cable transmission, is fed direct into the cable transmitter from the perforator.

The Commonwealth has a good number of these machines. They were seen at Adelaide,

Melbourne, and Sydney. The received tape was being gummed to the forms, and transmits were being sent from the Morse signals. Messages for local delivery were gummed to tape like the transmits, and were given to typewriters, who can reproduce them at the rate of fifty to sixty an hour. This was said to be of great assistance. The disposal of the tape in this manner hinders delay, and the transmits can be sent as well from the Morse tape as from written messages. This is in keeping with the experience in Britain. The gumming of the received tape is no more difficult than the gumming of the printed tape from Baudot, Greed, or the Murray automatic. Experience has shown that a man can gum slip coming at the rate of 250 to 300 average messages an hour, but this speed of reception is not usual. In the London Telegraph-office they do not gum the tape, but write it up at from twenty-five to thirty-five messages an hour. In Berlin Telegraph-office this copying of tape was seen being done at the rate of sixty to seventy messages an hour. A device had been arranged by which the tape was stretched before the typist, and on touching a key another length of tape was fed forward for typing. By this means the tape was easily handled at typewriter speed, as the typists did not watch the keyboard. Under the conditions prevailing in London it was found that gumming caused delay, as some messages were sent to various remote parts of the large office, and even on to a different floor, and would lie with others for a time before being transmitted. Any error then found obliged that the message be sent back for correction, which caused undue delay. By copying before distributing errors are detected early. An objection such as this does not apply to nearly the same extent in comparatively small offices.

On the London–Edinburgh circuits, at the Edinburgh end of which the "systematic Wheatstone" methods are employed, London uses Creed perforators and printers. This obviates the slow methods of writing-up referred to. About 2,800 messages a day are dealt with on these circuits. The use of this method enabled four circuits formerly in use to be closed, and cut out two repeater sets. It also reduced the delay upon the work. One day's work of eight hours on the Creed over two circuits was 1,720 messages, of which 1,170 passed over one circuit, or an average of 146 an hour. Three Gell perforators are used at each end.

Some of the newspapers have leased wires and work Wheatstone automatic between London and Manchester, about two hundred miles. These circuits are worked simplex at approximately two hundred words a minute. In the *Evening News* office they transmit to Manchester about forty thousand to fifty thousand words a night from 5 p.m. until 12.30 a.m. There are seven men at the London end, one in charge, four punching by manual method, and two using the Gell perforator. The manual punchers prepare tape without difficulty at twenty-five to thirty words a minute, and maintain that speed. It was particularly interesting to observe what could be done by that method. At Manchester there were eight men writing up. The *Manchester Guardian*, London, had eight men: five were manually perforating, and two were using the Gell perforator. One was attending to the transmitter. At Manchester there were eleven men writing. To ascertain the rate at which they were writing several of them were timed, and the speed was found to be twenty-five to thirty-two words a minute. At the *Daily News* office in Manchester there were seven writers, while at the London end there were four hand and two Gell perforators. Another couple of writers were required. The writers were timed, and the speed ranged from twenty-eight to forty words a minute. These newspaper offices at London and Manchester were visited with a view to confirming results that were said to be obtained, but that were difficult to accept without seeing for one's-self.

Some of the engineers of the British Post Office considered that the use of the "systematic Wheatstone" method would increase, and that it gave the best results; others were disposed to favour the Baudot system.

The Baudot is an old system, having been invented in France about thirty years ago, and it is most largely used in that country. Its principle is that several operators can use the same wire for transmitting messages practically simultaneously. A distributor is provided, with insulated segments arranged in circles or rings. Over these are revolved at a constant speed, either by a weight or small motor, brushes which wipe over the segments. At the receiving end there is a corresponding equipment. Provision is made for keeping the brushes in isochronism by correcting-currents sent twice every revolution. The brushes revolve about 180 times a minute. Each operator is provided with a keyboard which has five separate keys, so that positive or negative impulses may be sent to line. A signal called a "cadence" is given to each operator as an indication that the line is at that moment available for him, and he depresses his keys according to the letter that it is desired to send. A letter can be sent at every revolution of the brushes, so that thirty words a minute per operator is the maximum speed.

Baudot double, triple, quadruple, sextuple, have two, three, four, and six channels respectively. Sextuple is seldom used; quadruple is common. All of these can be duplexed. Quadruple simplex permits of 120 words a minute being passed over the line. At twenty words per message this gives ninety messages per channel: that is extreme. If fifty-five to sixty-five are got good work has been done. This system is very flexible, as all four channels can be used for sending from either end, or two can be sending and two receiving at each end, or three sending and one receiving. This is very convenient, as it admits of using the line for sending all in one direction and from either end. Quadruple will work on any circuit over which the Wheatstone automatic can be worked at ninety words a minute simplex. It would therefore work on all our circuits without the need of introducing repeaters. Tape is not used at the sending end, and at the receiving end it is gummed to message-forms and is ready for delivery as soon as it has been printed.

London works quadruple Baudot to Paris on four circuits, to Amsterdam on two, and to Lyons on one. Two channels of the Lyons circuit are used there, and two channels retransmit to Marseilles. These are through short cables across the Channel. Between London and Berlin a double duplex is worked through 250 knots of cable. Repeaters are used at each end of the cable. A quadruple Baudot set requires about two hours of a mechanician's time each day to maintain it in good working-order.

Between London and Birmingham, 120 miles, a quadruple Baudot on an underground circuit has been duplexed with very satisfactory results. From 8 a.m. to 8 p.m. as many as 4,044 messages have been handled on it. The senders had a man to sign and time for them. The circuit averaged over 3,500 messages a day for three months. The following are some figues—Eighteen men were employed, or eight operators and one man in charge at each end:—

Time.	1st.		2nd.		3rd.		4th.		Total.		Total each Hour.
	Sender.	Receiver.	Sender.	Receiver.	Sender.	Receiver.	Sender.	Receiver.	Sent.	Received.	
10 to 11 a.m.	38	36	55	49	59	48	52	51	204	184	388
11 to 12 ..	69	68	79	84	73	79	76	80	297	311	608
12 to 1 p.m...	67	53	53	43	71	35	60	47	251	178	429

The work from 11 to 12 is remarkable, and shows the capabilities of the instrument and of the operators; but such high results are not usual (see figures below):—

	Sent.	Received.	$4\frac{1}{2}$ men engaged each end for forwarded and received gives an average of
10 to 11 a.m. ...	223	253	... 50 sent and 56 received.
11 to 12 ...	224	254	... 50 ,, 56 ,,
Another day:—			
10 to 11 a.m. ...	233	257	... 52 ,, 57 ,,
11 to 12 ...	217	254	... 48 ,, 56 ,,

At other hours of these days the average per hour was less than quoted: it ranged from 42 to 50. This is due to the work not being there to do. During the following days totals were as below.—

	Forwarded.	Received.	Total.
December 19	2,027	1,867	3,894
,, 20	1,926	2,051	3,977
,, 21	1,919	1,915	3,834
,, 22	1,940	1,955	3,895
,, 23 (Saturday)	1,801	1,507	3,308

On the double duplex circuit, London to Berlin, from 8 a.m. to 8 p.m. from 2,500 to 3,000 messages a day are handled.

It was generally stated that it takes about three months to learn to operate the Baudot keyboard, and longer to become really expert. Apparatus is to be obtained by which tape can be perforated and fed into a Baudot transmitter, which passes the tape at thirty words a minute. A person can perforate the tape at a much higher rate than that. The advantage here is that the instrument can be kept fed at the utmost capacity available from the time of beginning to use the instruments, instead of having to wait to train men to use the keyboard. The ordinary keyboard can also be fitted so that it is easy to use either one or the other. This device, however, is not much used, as in France men learn Baudot as our operators learn Morse, and as it is there the Baudot apparatus is most largely availed of the tape transmitter is unnecessary.

In Berlin there was a good deal of Baudot working employed: a circuit to Cologne, 340 miles, and one to Warsaw, 400 miles. They were handling fifty to sixty messages an hour each channel on a quadruple. They use their Baudot only on overhead lines. The circuit to Paris, 750 miles, has a repeater at Coblenz, about midway. 200 lb. copper wire is used. The current is about 20 milliamperes.

In Paris Baudot is worked in the daytime on all long lines where there is heavy traffic. At night the Hughes is made use of. There were sixty Baudot sets, some sextuple, most quadruple, in one room. Two lines were worked sextuple, Paris to Marseilles, 500 miles, with repeaters at Lyons. On one line they send only Paris to Marseilles, on the other they send Marseilles to Paris. The wires are mostly 200 lb. copper. Some parts are iron, and they are underground in Paris for about twelve miles. On another 200 lb. copper circuit to Marseilles they work a quadruple without repeaters. A fourth quadruple Baudot on the same class of wire runs to Marseilles, where there are repeaters which enable them to work into three-cable circuits to reach Algiers. The cable is six hundred miles long. They have worked eighteen hundred miles quite satisfactorily, but, of course, repeaters had to be introduced. The repeaters at Marseilles are the most delicate part of the system. It was stated they handle six thousand telegrams a day on these circuits, and the repeaters, although delicate, do not require adjustment sometimes during a week. One mechanician was said to be required for every three quadruple sets.

Some Baudot sets are weight-driven; others are driven by small motors. On the weight-driven sets the weights are all wound up automatically by small motors. This was so also in London and Berlin. When motors are used for driving the brushes the voltage must be constant to avoid variations of speed. The maximum line-voltage used is 130. 20 milliamperes of current are sent to line, but 10 milliamperes are sufficient. No special attention is paid to insulation. If there is too much leakage another wire is substituted.

Baudot was said to be much easier for the operator to work than the Hughes. The number of messages per channel for Hughes or Baudot was considered to be practically the same. Hughes, however, can only be worked single and duplex, so that the line-capacity is not greatly raised by its use.

There are 100 complete Baudot sets in the Paris office. They are of all kinds—double, triple, quadruple, and sextuple—but chiefly quadruple. Men are paid on an average under £100 a year. Women who work at the Baudot receive two-thirds of a man's pay, and they do not work after 9 p.m. A day's duty is seven hours; at night nine to ten hours, but operators receive a bonus of 8s. 4d. per night in addition to their pay.

Five years ago the Russian Administration had no Baudot in operation: now they have over fifty sets of double and quadruple.

The Hughes is much used on the Continent, but only to a moderate extent in England. There were 250 sets in the Berlin central office. The quantity of work disposed of per pair of men was quoted as forty-five to fifty messages an hour when working duplex, and about fifty to fifty-five messages when working single. It is therefore about equal to a Morse simplex or duplex when these are worked fast.

At the Siemens and Halske works, Berlin, two very interesting telegraphic appliances were seen. One was most complicated apparatus, by which the tape, after being specially prepared, was passed through a transmitter at 600 words a minute, and was received photographically. It had been in actual use on two or three circuits in Germany, and was found to be sufficiently reliable, but unsuitable. The speed was much higher than was necessary, and the photographic feature caused it to be regarded with disfavour. The other appliance was an instrument by which tape was prepared from a keyboard. This operated five electro-magnets, which controlled the paper-perforations. There were distributors like those of the Baudot at each end, with revolving brushes. A frequency meter enabled the operators to see when the ends were in synchronism, and that they were maintained so. The signals were received printed on tape as in the Baudot and Hughes systems. This instrument has only recently been developed. The German Post Office is equipping two or three of its circuits with them. The speed is about one hundred and twenty words a minute. A perforated tape can also be received simultaneously with the printed tape. The circuit on which this instrument is used can be duplexed. The appliance is one that seemed to be capable of doing excellent work, but in the absence of any extended use of it we can only watch development.

Referring now to the American development, it has been seen that the Wright and the Morkrum can each handle on a duplex circuit during nine hours from one thousand to one thousand one hundred messages of about thirty words each, that being about the average length of the messages in that country. These are typewriter-keyboard systems working direct on to the line without the use of tape, the messages being received typewritten in page form. Only four persons are required, so that for each pair of operators the average is from fifty-five to sixty messages an hour. This is slightly better than is obtained from Hughes duplex, and is about equivalent to doubling the capacity of the operators and of our lines where duplex Morse is worked. Duplex Morse can be worked at that speed, but experience shows it is seldom done. First-class operators are not required, as the essential in the use of these instruments is a good typist. At the receiving end the attendant has only to watch the instrument and feed the forms.

The Wright machine, as explained, was undergoing change, which may be accomplished now. It would be advisable to have one or two circuits fitted with the Wright and the Morkrum apparatus to judge of their suitability for our conditions. These instruments are leased in the United States—they are not sold. From conversation with the manufacturers it was learned that there would be no difficulty about making satisfactory arrangements for the use of the instruments if such were desired. Neither manufacturer was at that time prepared to consider terms.

Quadruple Baudot would be very suitable upon several of our circuits. A set to Christchurch and to Dunedin would be equivalent, at sixty messages per channel, to about two quadruplexes, with the advantage of being able to use all channels in either direction according to the state of the traffic. These instruments are less exhausting on operators than the usual Morse work, and the receiving, which is only gumming of the tape to forms, does not require that the gummer should be an expert Morse operator. The output of the pairs of operators is about doubled as compared with the quadruplex working, and a most material consideration is that the capacity of the land lines and of the cables across the Strait, to which Baudot would be applied, would be also doubled. Delay to work would be much lessened, and it is reasonable to expect there would be a margin of outlet for extra traffic that does not exist at present. Many other circuits might be advantageously fitted with Baudot, such as two sets Wellington–Auckland each end; one set Wellington–Napier each end; one set Auckland–Napier each end; one set Wellington–Wanganui each end; one set Christchurch–Dunedin each end. All the channels would not be wanted at all these places, but they would be available at any time, and with growing business generally it is not desirable to install any Baudot double.

A point to be observed is that there is nothing experimental in connection with the apparatus mentioned. All of it is giving satisfactory service wherever it is installed. The Baudot has stood the test of thirty years, and is to-day in the very forefront of good telegraphic methods. So much is this the case that some modern inventors are not reluctant to admit that they avail themselves largely of Baudot principles in their efforts to devise fast-speed machine telegraph apparatus. Two circuits between Wellington and Auckland would probably be most suitable to begin with.

At the four large centres—Auckland, Wellington, Christchurch, Dunedin—and a few other places it would be economical and advantageous to install accumulators to be used for telegraph-line batteries. These would be much more satisfactory than primary batteries. The voltages would remain practically constant even under heavy output in times of low insulation, greater constancy of working would be attained, and considerable space would be released which the primary batteries now occupy. The use of accumulators prevails at all the principal offices in Great Britain and on the Continent. The dynamo method used in the United States is not so simple or so flexible as the accumulator method of providing line-current. Accumulators are already used in several places in the Department for working local circuits, with gratifying results.

Wireless Telegraphy.

On arrival at San Francisco, the United wireless station on the outskirts of the city was visited. It was situated on elevated ground, with the two masts still higher up on the sloping hill. The power installed was 10 kilowatts, so arranged that it could be halved. In the night-time the full power was used, and communication was obtained with Honolulu at a distance of 2,100 miles. Ships frequently got into connection with this station at a distance of 1,500 miles and over at night. In the daytime, while there were wireless signals to be heard almost at any minute, no effort was made to attain distances beyond two hundred to three hundred miles. An operator was continually listening.

It was noticed that there was a large number of aerials scattered over the city. Some of the owners of these had power up to 2 kilowatts installed, and as there was no regulation of wireless it was found that from 7 p.m. until 10.30 p.m. there was a great deal of interference. The night before reaching port the officer in charge of the wireless on board the ship kindly permitted me frequently to listen. It was found that several stations were generally working at the same time, and, notwithstanding that, were managing to get along fairly well. To assist in reducing the interference and to expedite naval and commercial work, there was an unwritten understanding that one class of work was to be done during one half-hour and the other class during the next half-hour. This arrangement was of considerable advantage.

From the United wireless station another station was seen nearer to the sea. This was visited, and proved to be that of the Poulsen Development Company, which was operating the Poulsen arc system. Some time was spent investigating this system, which was found to be getting very good results in the daytime. The power was about 12 kw. The two masts were 300 ft. high, and a harp antenna of about forty wires was used. The system uses undamped or continuous waves. Communication could be obtained at any time with Los Angeles, about five hundred miles distant, and for many months for eighteen hours a day El Paso, one thousand miles distant overland, and with mountains 14,000 ft. high intervening, had been in uninterrupted communication.

Stockton, eighty miles north, with 4 kw., reached Los Angeles without difficulty in the daytime. A demonstration was given whereby the continuous waves were broken up so as to render it possible for signals to be received on a crystal or other detector suitable for receiving spark-waves. The communication with Los Angeles by this method was satisfactory. When continuous waves are radiated a "ticker" has to be employed. Telephonic speech to Stockton, eighty miles distant, was exchanged, and found to be fair.

Stockton and Sacramento both sent telegraphic signals simultaneously, and either could be easily cut out so that the listener was quite unaware that there were any signals arriving from the second station. This was effected by quite a small movement of the tuning condenser.

For several days during a breakdown of land wires the business of the Stock Exchange between San Francisco and Los Angeles was conducted by this system, and the manner in which the work was done received the written approval, which was read by me, of the authorities of that institution.

Honolulu, 2,100 miles distant, was reached sometimes at night, although the antenna there was small. A higher antenna was to be installed and 30 kw. used at San Francisco to cover the distance. Information has not reached me whether that was successfully done.

This system was giving great promise, and the company was erecting a station at Fort Worth, and was about to erect one at Chicago to engage in the commercial transmission of telegrams.

At Los Angeles there was a station similar to that at San Francisco. It was seen, and the writer chanced to be listening there when San Diego, at about 3.30 p.m., first attempted to speak to San Francisco. The result was satisfactory. San Diego had 4 kw., and is about 550 miles from San Francisco and 120 miles from Los Angeles.

The next wireless station visited was that of the United Wireless Company, on the Congress Hotel, Chicago. This was on the roof of the hotel, the masts being only about 60 ft. high and separated about 100 ft. The power was 2 kw. This station is used for communicating with vessels on the great lakes. There is no desire to attain long distances, as there are coast stations along the lakes. The next one was at Milwaukee, 100 miles distant. By not having too great a range there is much freedom from interference of stations with each other. There is a great deal of shipping on the lakes, and many ships are fitted with wireless, mostly of the United Wireless Company's system.

In New York the Telefunken system was installed on the roof of Trinity Building. The power was 2 kw. The masts were only about 70 ft. high, with about 120 ft. between them. Distances up to seven hundred or eight hundred miles were attained at night.

The Naval wireless station at Brooklyn Navy Yard was of 2 kw. The aerial was supported on two masts about 150 ft. high, and separated about 300 ft. The day range was about two hundred and fifty to three hundred miles. A man was continually listening. There were no special features.

At Washington Lieutenant-Commander Todd, of the Navy, was seen and spoken to upon wireless matters.

The Navy is building at Washington three masts 600 ft. high. It appears that Professor Fessenden, who had tendered for a high-power station to have a range of three thousand miles, for some reason or another did not undertake the work. The Navy is erecting the poles, and will use the Fessenden apparatus, which it is understood they now have. It was learned, but not from this source, that the Telefunken system in powers of from 2 kw. to 10 kw. is used to a considerable extent in the American Navy, and that it is found to give satisfaction.

The amateur in wireless is in evidence about New York just as he was at San Francisco, and is stated to be not any less troublesome.

The Marconi system is largely used on the Atlantic liners. Press is sent out every night from Poldhu in England and Cape Cod in Canada. By this means steamers are able to keep in touch with the news of the day from one side or the other of the Atlantic, even though they may be unable to be heard by the coast stations. It was noticed that ships often get other ships to transmit messages for them, and thus vessels out of range of the originating vessel can be reached.

In Germany a visit was paid to Eberswalde. This is an experimental station of Messrs. Lorenz and Co., who were experimenting with the Goldschmidt system. They also had the Poulsen. There were two masts of 250 ft. height, upon which were two aerials—one an umbrella, the other T-shaped. About half a mile distant there was another small station with mast about 80 ft. high. A counterpoise was used. Here were heard tunes that were being played at the other station, and we were informed that these tunes can be heard quite well at Berlin, forty-five miles away. The Goldschmidt apparatus was not in order, so no opportunity of a demonstration existed.

The experimental station of the Telefunken Wireless Company at Nauen was visited. Unfortunately the aerial here was dismantled, and the whole station was being practically rebuilt. The iron mast, which was formerly 325 ft. high and mounted upon a marble slab which had become crushed, was jacked up to enable new insulators of glass to be introduced, and a further 325 ft., half of which was at that time in place, was being added. When completed, the iron mast was to be 650 ft. high. The first mast was triangular in shape, and had 11 ft. sides. The top portion was being extended as a triangle also, but with reduced length of side. There were eighteen masts about 100 ft. high on the circumference of an area half a mile in diameter. These were for supporting the outer ends of the umbrella aerial. A new brick building of large size had been erected, and power boards, generators, and wireless apparatus generally were being installed. The power was to be 250 kilowatts. One-half was to be devoted to a generator that was designed to produce direct currents of a frequency of about 50,000. The station was expected to work to New York when completed, and it is understood that this end has been attained. It has appeared in the Press recently that the tower referred to was blown down during a gale.

The head office, store, and works, where the less heavy apparatus is manufactured, were inspected, and the utmost pains were taken and courtesy shown in explaining and giving demonstrations of various features

A resonance signal amplifier was shown in operation. Morse tape on which had been perforated the word "Paris" was passed through a Wheatstone transmitter. On listening on an ordinary telephone receiver adjustments were made until the word was scarcely audible. A switch was then thrown which brought in the amplifier, when the signals became so intensified that on entering an adjoining room they were heard distinctly and loudly. It was then shown that the weak signals referred to were so amplified that they could operate a relay, which in turn caused them to be recorded on tape by means of a Morse register. The amplifier can also be used to record rapid signals up to about sixty-five words a minute.

One of the troubles attending wireless work is that an operator has to be continually wearing a telephone receiver so as to detect calls. This company has a call apparatus which rings a bell at the receiving station. The apparatus does not respond to static or to general signalling. It consists of a highly sensitive galvanometer whose needle is deflected and mechanically held when it makes a full excursion, and at that point a local circuit is closed which rings the bell. In order to call it is necessary for the calling station to hold the key depressed for several seconds. These radiations enable the galvanometer-needle to gradually increase its deflection until its full movement is attained, when a tooth engages and depresses it. Depressions of the key for shorter periods do not allow the galvanometer-needle to move so as to be carried to the point of completion of the local bell circuit. A 3 kw. set was seen in operation fitted with an automatic starter, so arranged that by merely closing the main switch the motor generator was brought up to speed in about fifteen seconds. In conjunction with the transmitter of this set was a receiver fitted with an automatic break-in relay. Normally the station is in position for receiving. To send it is necessary only to operate the key. When the key is again released the receiver is automatically cut in. The receiver, however, does not cut in during the spaces between letters, but only between words. It is thus possible for a station sending to know whether the receiving station is breaking or not. For operating stations where the power to be used is large—say, 30 to 40 kilowatts or more—the company uses a relay key. This has large contacts and considerable break. It has also large surface, so as to permit of heat radiation. An ordinary key or Wheatstone transmitter can be used to work the relay through a local circuit.

Special care is taken with the manufacture of detectors. They are made of varying degrees of sensitiveness. Many of these were tried, and with the special method and apparatus devised for experimenting with them it was possible easily and quickly to determine the merit of each so far at least as sensitiveness was concerned.

On going through the store, it was found to be so well stocked with apparatus, mostly made up, that one could not help expressing surprise at the quantity. It was, however, stated that the company had received orders for about 350 sets of various powers during the year, so that they found it desirable to hold large stocks. Military sets were on exhibition. These were mounted on vehicles in some cases, and in other cases were suitable for conveyance on horses.

As already stated, the lighter work only of the company was dealt with at their own works. The ordinary manufacture of Telefunken apparatus is conducted by two large electrical firms, Messrs. Siemens and Halske and the Allgemeine Electricitats Gesellschaft, of Berlin. The works of the latter company were visited, and there were seen assembled the transmitter spark-gaps, the banks of glass condensers, the various inductance coils, and the means of altering their relative positions and the class of insulation employed. This assembly of apparatus which was to be used in the New Zealand station presented a fine appearance, and left the impression that the company was desirous of supplying equipment suitable to compass the distance that was called for.

Owing to the experimental station at Nauen being dismantled for alterations, it was not possible to get an exhibition of high-power working: only working over limited distances was available. There is a high-power station at Pola, on the Adriatic. This is of 20 kilowatts primary energy, and operates with about 10 kw. in the aerial. The company very kindly arranged for Pola to send. An officer of the company accompanied me to Copenhagen, and arranged with the Danish naval authorities that access be given to their station to listen to Pola. The distance is about seven hundred miles overland and across the Alps. The two masts at Copenhagen were about 200 ft. high, separated about 300 ft. They have three aerials on these masts. There was no difficulty in picking up the signals from Pola, which were clear but not very strong. Pola did not, however, hear Copenhagen, the power at that station being only 2 kw. We were informed that it is not unusual for Pola to pick up the Copenhagen station signals.

Very good accounts were given by the Danish officers of the working of the Telefunken system. There are twenty-two installations in Denmark, most of them ship stations. The Copenhagen station reaches out seventeen hundred to two thousand miles often at night, and hears ships at similar distances. They have the spark-gap system as well as the quenched spark gaps, and they find they can reach Marconi ships better with the former, although they find the quenched sparks better for working to ships fitted with Telefunken apparatus.

Opportunity was taken of seeing the Poulsen system in operation at Lyngby, about ten miles out of Copenhagen. Dr. Poulsen very kindly arranged for a demonstration to be afforded me. The corresponding station is at Cullercoats, near Newcastle, England, and the distance over water about 560 miles. There are two masts, about 200 ft. high and 350 ft. apart. The simplicity of the equipment was a striking feature. There is no noise when sending. This system operates with continuous or undamped waves generated by an arc in a magnetic field and a hydrogen atmosphere. The arc was easily struck, quite manageable, and burned with evenness. At one time carbons used to consume too quickly. That difficulty has been overcome, and by a simple treatment of the carbon it is found it will last for hours. An ordinary key can be used when sending, as the current into the aerial does not pass through it. On each depression of the key a few turns of coiled wire constituting inductance are short-circuited. This variation of inductance in the circuit alters the wave-length, and as the receiving station is tuned to this wave-length response is made to these signals only. The reception was by a tellurium-galena detector. Signals were quite freely exchanged at about twenty-five words a minute at 3 p.m. A switch was arranged by which the usual telephone-receiver was cut out and a receiver with a trumpet mounted on it—a sort of amplifier—was cut in. The signals could then be heard about 3 ft. distant from the trumpet.

This company has worked out devices by which high-speed wireless working has been accomplished. The transmitting-apparatus of this system was shown and explained. Tape perforated similarly to that used for submarine cable transmitting, on being passed through the apparatus, controls pins so that contacts are made round the edge of revolving discs, and vary the wave-length just as the depression of the key does. A string galvanometer is used for receiving. The vertical wire of this instrument is in a strong magnetic field. The received currents deflect the wire slightly. The shadow of the wire is then projected by a powerful electric lamp through a microscope, which magnifies its movements. These movements cause a wavy line to appear upon a vertically moving strip of photographic-paper. The paper is developed and fixed while the apparatus is working, and emerges with the signals distinctly impressed upon it. This was not seen in complete operation. The string galvanometer was at the works at Copenhagen. Lyngby, however, sent some signals, and the galvanometer movements were quite clearly discerned.

Some experiments were recently made between Tralee, Ireland, and Lyngby, 950 miles, at speeds varying, according to atmospheric conditions, from 65 to 145 words a minute. Forty horse-power was available for transmitting purposes. Sometimes signals were not got through by the automatic methods, but hand working was at all times possible. The results indicate that high-speed wireless work is practicable, and there can be little doubt that a few years will see useful development in that sphere. Other companies are working in the same direction. Considerable power would appear to be required.

The wireless station at Schevingen, which is a Government station of Holland, was seen. There is a first-class brick building, large and well equipped. This place is only three or four miles from The Hague, and the station is amongst the sandhills, a little back from the sea-beach. The two wooden masts are about 330 ft. high, 350 ft. apart. A harp antenna of twenty-one solid bronze wires is employed. This is one of the best-known wireless stations in Europe. The staff is always on duty, and they cover distances up to two thousand miles at night. It cannot be said to be any particular system. The officer in charge has been associated with wireless from its beginning, and has made use of the best of the different systems. In a large room they have three or four separate sets. They use spark-gaps of zinc, a somewhat flattish surface is employed, and the distance between plates is about $\frac{1}{4}$ in. The voltage reaches 40,000. The maximum power is 9 kilowatts. To get power they drive a dynamo from the town supply at 220 volts D.C. With this they drive a D.C. motor, which is coupled to the alternator. As a standby they have a set of accumulators of 100 ampere-hours capacity and 220 volts, from which they drive the motor-alternator should the town supply not be available. The battery will last about three-quarters of an hour continuously running, and this has been found to be sufficient. Some distance away in a small shed they have an oil-engine and dynamo, which can be started up if all other sources of supply fail. They leave nothing to chance in having a supply of energy available. Electrolytic, crystal, and valve detectors are used. Greenwich "time" for shipping is sent out daily at noon from this station. This was heard on one occasion at the Telefunken station at Messrs. Siemens Bros.' works at Woolwich. The signals were excellent at that distance.

The works of the Marconi Wireless Company at Chelmsford were visited, and were found to be very interesting. Here were several sets of apparatus up to 10 kw. being prepared for testing. The workshops were large, and from the number of men employed it was evident that the wireless apparatus of this company was in demand. The most striking piece of work was a huge primary of a transmitting-jigger, which it was said was being made for the high-power station at Coltano, in Italy. This primary consisted of a single turn about 5 ft. 6 in. in diameter, made up of some hundreds of separate insulated wires laid up on a wooden core. Their military sets were of excellent design and manufacture, and were very compact.

This company very kindly invited me to visit as their guest the high-power station at Clifden, in Galway, which is used to communicate across the Atlantic Ocean with the company's station at Glace Bay. There are 1,000 kilowatts of power installed in two units of 500 kilowatts. The generating-station is quite an electric power-house, and is detached some distance from the building in which the transmitting-apparatus is placed. Cables underground convey the current to the apparatus-room. Steam power is used to drive two or three alternators, which generate current at 2,200 volts. This current is used to drive four motors, which are coupled to dynamos, each of which gives about 5,000 volts direct current. This direct current is used for charging accumulators which are used in transmitting. The steam at present is coal-produced. Alterations to the general lay-out of the steam-engines were in progress to provide for the use of peat as fuel. There are large areas of peat bog, and large quantities of peat are already cut. It is intended that there should be small cars filled with peat forming a sort of endless chain. These are to circulate in a closed-in chamber into which the waste heat from the furnaces will escape. By this means the peat put in at one place quite damp will arrive at the furnace-doors sufficiently dried for use. Coal is very expensive, as it has to be handled much. The accumulators and condensers were in the transmitting-apparatus room. There are about seven thousand accumulators of about 100-ampere-hours capacity. These are arranged so that if any work is to be done upon them they can be broken into sections to avoid risk of dangerous shock. They are not placed upon stands, but are suspended from the ceiling, each cell being carefully insulated with porcelain. The condensers are composed of great plates of iron hung vertically. The building is of wood and iron, two stories, and these plates extend over a large portion of the building for its full width and from the ceiling level almost to the ground. The plates are separated from each other about 6 in. or 8 in., and form what are known as air-condensers. The capacity is about 1·8 microfarads. Arrangements are provided by which plates may be cut in or out as required. The coupling between the primary and secondary coil is loose. These coils are provided in duplicate. The primaries are of the type referred to as seen in the works at Chelmsford being made up for Coltano. The secondaries consist of eight or ten turns of specially-made-up wire in the form of a rope. The turns are separated from each other by several inches, and are about 2 ft. 6 in. in diameter. There is no difficulty in quickly transferring from one set of coils to the other if necessary. A rapidly revolving disc between two more slowly revolving and smaller discs is used for the spark-gap, in conjunction with which blowers are employed. The power that was being used was about 120 to 130 kilowatts. Sometimes the distance can be compassed with 10 kilowatts; at other times much more than the maximum mentioned has to be used. The noise when the station is transmitting is deafening, and can be heard for a long distance. Before entering the building it is usual to stop the ears with cotton-wool. You cannot converse inside: it is necessary to come outside and close the door, which confines the noise somewhat. The aerial is supported upon eighteen masts. Sixteen of these, in four rows of four, about 200 ft. high, extend away from the station for about half a mile in a direction opposite to Glace Bay. The width is about 1,000 ft. The receiving-aerial is distinct from that used for transmitting, and is composed of two wires, which, besides extending over the whole half-mile referred to, are also carried forward about 1,500 ft. on to two other masts placed near the receiving-station. This station is removed from the transmitting-station about 500 or 600 yards. When inside the noise of the transmitting-station cannot be heard. Wires are run underground, and the manipulator of the Morse key in the receiving-station closes a circuit through a special relay at the transmitting-station, and so controls the high power. In the receiving-station it is arranged that when sending on the Morse key a low buzzing sound from a small spark is heard, so that the operator may know that the high-power signals are being emitted. The apparatus for receiving is very little more complicated than an ordinary ship's set. The Fleming valve is used as a detector. Telegrams are sent at a speed ranging from fifteen to twenty-five words a minute, according to the capabilities of the sending operator and the amount of business. It was noticed that two or three telegrams are sent in succession. The receiving-office does not repeat them, nor are they repeated by the transmitting-station, but request is made for repetition of any word that has not been clearly received. The writer listened to the signals from Glace Bay. These came clear and strong, and there was no difficulty in reading them. The note was good and flute-like. Simultaneously at about 10.30 a.m. signals from the station at Coltano were heard. These were from alternating current, and were less musical and not nearly so loud as those from Glace Bay. There was no difficulty in reading the Glace Bay signals while Coltano signals were coming, and when Glace Bay ceased Coltano was easily read.

There was a good deal of traffic being dealt with. In a separate room the instrument for use on the land line was seen. This line seemed to be kept well occupied, and it was said they were considering the matter of duplexing it.

It was the intention to work duplex by wireless across the Atlantic, and a station for receiving was being erected about fourteen miles north of the existing station. The proposal was to operate the transmitting-station from the receiving-station over wires run either underground or aerially, the wires to be insulated throughout their entire length in either case.

Long wave-lengths are employed, ranging from 6,000 to over 10,000 metres, and it was stated that sometimes better results were got with the shorter than with the longer waves.

There was no interference from any station except that at Coltano, which had been operating for only a week or two at the time referred to. Coltano is a high-power station erected in Italy to work to the Argentine, when a large station which is contemplated there has been completed.

The impression received from what was seen and heard at Clifden was that wireless-telegraph work was being carried on in a businesslike and reliable manner, and that there was a fair volume of business, both Press and commercial work being handled. The weather was fine, and there was no interference from static experienced. There are, of course, times when static is present.

Messrs. Siemens Bros., who are the agents in London for the Telefunken system, had installed a couple of wireless sets at their works at Woolwich for experimental and demonstration purposes. One was of 10 kilowatts. Their two masts were 120 ft. high. They had reached Berlin, about seven hundred miles, in the daytime, but the terms of their license limited them to quite a short period of working and to 850 metres wave-length, which was not altogether suitable for the distance.

At Boulogne there is a station equipped with the Bellini-Tosi directive system. The aerials are arranged to serve two purposes — that is, to communicate in all directions or in a particular direction, as may be necessary. There are four iron lattice masts each 145 ft. high placed at four corners of a square having sides about 250 ft. long. From each side of the square six parallel copper conductors are suspended from a wire stretched between the masts and insulated therefrom. These parallel wires are separated from each other about 12 ft. They are not dropped vertically, but are inclined outwards, and are secured at a height of about 25 ft. from the ground and 60 ft. from the vertical to another supporting-wire stretched horizontally between the poles. The suspended wires, which are carefully insulated from the lower supporting-wires, are then stretched horizontally to insulators on the roof of the operating building placed in the centre of the square. A motor generator of 7·5 kilowatts is available for charging a battery of accumulators of 350-ampere-hours capacity. The spark-gap of the exciter circuit consists of two bell-shaped metals, with the edges turned well back, placed opposite each other and about a quarter of an inch apart. The spark forms at different points between the bell-shaped metals. The battery of condensers in the exciter circuit consists of Moscicki tubes. These are of good capacity and superior insulation. The primary and secondary coils for both transmitting and receiving are wound upon frames, and so disposed that one rotates inside the other. To direct waves in any direction the primary is turned to that direction; similarly to receive waves. The aerials are suitably and quickly connected to or disconnected from the sending and receiving coils by throw-over switches which have mercury cup connections. There are three detectors of iron-pyrites. This system has not given the results that were expected.

There is a fine wireless station of Lloyd's at Port Said. There are seven masts; the central one is 180 ft. high, and the others about 50 ft. above the ground. Three are on the building adjoining. The aerial slopes away in two directions from the top of the pole to the smaller poles, and consists of fourteen 7/32 phosphor bronze wires on each side. The guys are not broken by insulators. There are 110 storage cells of 38 ampere-hours at ten hours discharge. The petroleum-engine of 12 kw. runs a dynamo of 6 kilowatts for charging the cells. The spark-gap is of the rotating type. There are two 2½ kilowatt transformers giving 20,000 volts. The condensers are of the case type, and consist of zinc separated by glass plates in oil. The range of the station is about four hundred miles by day and up to fifteen hundred miles at night. As receivers they use the magnetic detector and crystals. Malta and Aden, each about a thousand miles distant, are always within range at night. It was stated that signals from Ipswich and Norddeich are heard quite regularly, and that Pola, on the Adriatic, comes in so strongly as to be interfering. Atmospherics are very bad at times, but it was said that the note of the Telefunken spark could be read through them. They hear ships fitted with the singing spark far beyond Aden. Their present equipment has been in operation only a few months. Prior to its installation the wireless station was at the lighthouse a few miles distant, and the range was only about three hundred miles at night. Induction coils giving a 10 in. spark were employed.

At Perth one of the high-power stations of the Commonwealth was nearing completion. It was not visited. The iron mast, about 400 ft. high, was seen towering in the distance. The station, although incomplete, was being tried with small power at night, and communication between it and the ship was maintained for two or three nights after leaving Fremantle. This station, when completed, was to have a range of 1,250 miles in the daytime.

The Sydney station at Pennant Hills, of power and range, when completed, corresponding to that at Perth, was visited. It occupied about 100 acres. The main pole, 396 ft. high and of iron, was a solid-looking, well-built structure, strongly guyed to anchors firmly bedded in massive concrete foundations sunk in the ground. This mast was the central support for the umbrella aerial, which was supported on the outside by wires taken to ten poles each about 100 ft. high and placed around a circle of large diameter. These poles were of wood, and were stayed with wire in all directions. Alterations were being made to them, as they were somewhat warped and did not look very presentable. The station was not in working-order, as some changes in the position of machinery in the power-house were in progress. The operating and apparatus rooms were comfortable, and appeared to be neatly equipped. The spark-gaps, condensers, and inductance and other coils were similar to those seen at the Allgemeine works at Berlin, which had been manufactured for use in the high-power stations of this Dominion. Alterations were undertaken before this station had been working long enough to enable definite conclusions to be formed as to its range. To determine the range it will be necessary to wait until the station is completed and has a suitable station to correspond with, and until trials over a period of time have taken place.

The Commonwealth Government has decided to build its own stations upon a system stated to be that of their own wireless expert, Mr. Balsillie. The power of these stations will not exceed, say, 5 kw. to 7 kw. The first of these stations, erected in the Domain at Melbourne, was seen. The mast is made up of Oregon pine beams, 15 in. by 3 in., bolted to form a mast 185 ft. high and 21 in. square throughout its length. The foot is imbedded in concrete. The aerial of umbrella form consists of a few wires extended outwards and anchored at about ground-level some distance from the base of the mast. The building is about 25 ft. by 30 ft., and is of two rooms. Permission was given to see the operating-room, which contained nothing unusual. The inner room contains the apparatus, which is kept from the observation of outsiders. Recently it was reported that the Marconi Company had proceeded in the Courts for permission to inspect the whole of this station. Judgment was given in their favour, with the proviso that secrecy was to be maintained as to the station. It was stated the permission was not accepted on these conditions. The working of this station was said to be very satisfactory.

A similar station was seen in course of erection at Hobart, which is now finished and giving satisfactory results. The erection of several other stations at different points was to follow.

The officers of the wireless department of the British Post Office were spoken with, but there was nothing of any special significance elicited. Their principal stations are at Caister, North Foreland, Bolt Head, Seaforth, and Cookhaven. These are all of 3 kw., except Caister, which is 1½ kw. They have stations at Niton, Lizard, Malin Head, and Rosslare using 10 in. coils, but the power of these is to be increased. Niton and Malin Head are being made 3 kw. and 5 kw. respectively. The Lizard station is to be removed to Land's End and 5 kw. installed. The Rosslare station will be removed to Fishguard, with 3 kw. installed, and a new station of 10 kw. is to be opened at Valentia, on the west coast of Ireland. The Marconi system is used. Masts are mostly 150 ft. high. Aerials are of different forms, such as cage type, umbrella, L form, vertical two wires, and ordinary four wires—that is, a central mast with four wires radiating outwards to four smaller and lower masts. Licenses are granted for experimental purposes for operating during certain hours; these impose conditions as to tuning and wave-length. The officers expressed themselves as interested in the high-power wireless undertakings in this Dominion.

While in London an effort was made to arrive at some conclusion as to the situation regarding the patents in respect to wireless installations in New Zealand. Nothing definite, however, could be arrived at. The Marconi Company claimed that the Parker judgment delivered in connection with the action against the Amalgamated Radiotelegraphic Company established that all companies engaged in the supply and operation of wireless telegraphic apparatus and installations were infringing the Marconi patents. So far as New Zealand is concerned, there would appear to be only two principal companies involved—viz., the Marconi Company and the Australasian Wireless Company (Limited)—supplying and operating the Telefunken system. The parent company of the Telefunken system in Berlin claimed that their system in no way infringed the patents of the Marconi Company, and actions of each company against the other had been begun but had not come to a hearing. Various opinions were expressed by persons acquainted with wireless matters. No dependence, however, can be placed on mere opinion in connection with such a matter, and until a Court has pronounced judgment the question of infringement must remain in its present indefinite condition.

The Lodge patents, of which an extension of certain claims had been granted by the Court for a period of seven years, have been purchased by the Marconi Company. One of the conditions of the extension was that licenses were to be granted on reasonable terms to persons wishing to use the system. Application was made to the Marconi Company by the British Insulated and Helsby Company (Limited) for a license, but difference arose as to what were reasonable terms. The result was that the question was referred to arbitration, and the hearing was taking place during December and January, but was not open to the public.

In conclusion, it is desired to say that everywhere the utmost kindness and courtesy were extended to me, and every facility was afforded me as the representative of the Department to obtain information and insight into the methods of working and other aspects of the matters that were being inquired into. So generally was this the case that it would be invidious to single out any particular persons, firm, company, or Administration for special notice in this connection. One exception should be made to the above by stating that Mr. Llewellyn Preece, of the firm of Messrs. Preece, Cardew, and Snell, and Consulting Engineer in London for the Department, was untiring in his efforts to facilitate in every way my endeavour to get into touch with various matters; and on many occasions he made all arrangements and accompanied me to places where demonstrations of special apparatus or appliances were being given. His special knowledge, which enabled him to determine where matters of interest were to be found and how to get into touch with them, was of much assistance.

T. Buckley,
Chief Electrician.

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